PROCEEDINGS

OF THE

YORKSHIRE

Geological and Polytechnic Society.

NEW SERIES.—VOLUME IX.

1885-1887.

With Thirty Plates.

EDITED BY JAMES W. DAVIS, F.G.S., F.L.S., &c.,
HONORARY SECRETARY.

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PHOTOGRAPHS.

Three Photographs are issued with the present volume of Proceedings. They illustrate Contortions in the Chalk at Flamborough Head. Some account of the Contortions will be found on page 43.

Vol. IX.] [Part I.

PROCEEDINGS
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1885.

ON THE WORK AND PROGRESS OF THE SOCIETY. BY THE MARQUIS OF RIPON, K.G. (PRESIDENT).

The Marquis of Ripon, who was received with applause on rising to address the meeting, said it became his duty to make some observations to them on taking the chair on that occasion after an absence of five years from the duties of his office as President of that Society. He could assure them that it afforded him great pleasure to meet once more the members of the Yorkshire Geological and Polytechnic Society after having been so long separated from them, and from his other friends in the county, by the public duties which he had been discharging in a distant part of her Majesty's dominions. He always felt, when called upon to address the members of the society, how very little worthy he was to offer any observations to gentlemen who were so much better acquainted with the scientific subjects to which the society devoted its attention than he was himself, but as it had been now for many years their good pleasure, and also their great kindness, to keep him in office as their president, he was glad to have from time to time an occasion of assuring them how very much he valued that position, and how grateful to them he was for continuing to him their confidence by electing him to fill it. If upon other occasions he had felt the difficulty of addressing men who were his superiors in scientific knowledge he felt it very much more in some respects upon that

occasion, because he was altogether five years behindhand with most of those who were present in his knowledge of what had been going on in the scientific world, for he had had other things to do during the last few years than to devote himself to keeping up even a superficial knowledge of the progress of science during that time. Any man who fell behind that progress for such a period as five years in these days when science is advancing with such rapid strides must be altogether behind his time with regard to it; for though he had visited a country in many respects interesting from a geological and scientific point of view, and though he dwelt for a large portion of the year not very far from those Sewalik hills which were so interesting to geologists, he was not able to study any of the geology of India, and he therefore could not give them any information upon those interesting matters which might have come under his notice if he had had time to devote himself to them. But he could, however, say that the Government of India were well alive to the importance of scientific investigation, and recognised it as part of their duty to encourage it as far as they could consistently with their financial means. But coming back after a lapse of five years, he had naturally been anxious to ascertain what had been the course of the society during that time, and what progress it had made in the work to which its members are devoted, and he consequently made an appeal to Mr. Davis, their excellent secretary, whose services to the society he was sure they all must cordially recognise, to give him such information as would enable him to form some judgment as to the way the society, during the last five years, had been maintaing the position which it occupied the last time he had the pleasure of filling that chair, namely, in the commencment of the year 1880. And he was very glad indeed to find that during that period, so far as he could judge, the work of the society had been successfully carried on, and that it was now in a satisfactory position. Looking back to the list of papers which had been brought before the society during that time, he thought they would all agree with him if he said they had been of a description fully to maintain the reputation of the society. He found ample proof of that in the value which appeared to have been attached to

some of these papers by very competent judges not connected with the society. Take, for instance, the papers which Mr. Lamplugh had read at various times in connection with the geology of the district about Bridlington and Flamborough. In these papers that careful geological investigator had traced out and correlated the glacial deposits of that district, and he had done so so successfully that, as he understood, the maps, plans, and sections of his papers had been adopted in the report of the General Geological Survey prepared by Mr. Clement Reid, and these papers had been made the basis of the report upon the geology of that district. That was a circumstance which he thought showed that impartial judges attached great value to the papers that are now read before the society. Again, a very interesting series of papers, of a highly technical character, however, he imagined, had been submitted to the society by Mr. Vine, on the fossil Polyzoa of the Carboniferous Limestones. A paper upon that subject was promised for that day, and he believed notice would be taken of it, although Mr. Vine was not present. He was a person of so great authority in connection with those curious fossil creatures that he had been invited by the British Association to prepare a paper on the subject. He had also read various papers before the Geological Society of London, and that showed that the members of the Yorkshire Geological Society, and those who were willing to take part in their proceedings, are men whose labours are appreciated, not only in that limited society, not only among the scientific men of the great county of Yorkshire, but in the country at large. Then again, there had been interesting papers, he believed, read in connection with the microscopic structure of some of the fossil plants found in the coal measures of the neighbourhood of Halifax, and he had been himself particularly interested in finding that explorations had been carried on at Dowkerbottom Cave, in the neighbourhood of Kilnsey, by Mr. Poulton, who was assisted by a number of students from the University of Oxford. Having conducted these explorations, he had been good enough to communicate the results to that society—results which he believed were full of interest. But the point in regard to these explorations which particularly attracted him was

the fact that fifteen students of colleges at Oxford should have spent their vacation in undertaking work of that kind out of love for geological science. Last year the society went very nearly into his own neighbourhood to hold one of their meetings—they held a meeting at Harrogate, and he was particularly sorry that he should have been absent at the time, and not able to take part in the meeting on that occasion. Their attention was then naturally directed to those extremely savoury and delightful waters which are to be found at Harrogate. They doubtless investigated all their various qualities, and he perceived from the list of papers which had been shown him that a very considerable number—what he thought it was the fashion in these days to call a symposium of papers—was read upon the subject of the analysis of the Harrogate waters—a very natural subject for a symposium. There was one circumstance connected with these papers which had been exceedingly interesting to him individually, because he found that one of them was read by a student of the Yorkshire College, who had devoted himself to the subject with which the paper dealt at the suggestion of his friend Professor Thorpe. It was very pleasant to him, connected with that college, to find that one of its students had been engaged in an investigation of that kind; and he took that opportunity to express a hope that other students would follow the example of Mr. Whiteley, and do original work and conduct observations, and that they would do the society the honour of publishing them in their proceedings. They would all be aware that the society had been engaged in works of exploration at Raygill, which he understood had been stopped for a considerable time in consequence of a huge mass of rock which required to be removed. He was glad to say that the difficulty had now been overcome, and that the work had been resumed, or would be shortly. He thought that the facts which he had briefly recounted of the work which had been done in the past five years were sufficient to convince them, and the public outside, that that society was not merely a dilettante society, but that it was doing good, substantial, scientific work calculated to confer real benefit upon the county, and to promote the best interests of science. He hoped that they would not think

that he had indulged in that retrospect simply because he happened to be absent from his duties as President of the Society for a certain period. He thought it very advantageous that a society of that kind should from time to time take stock of its work, that it should consider what it was that it had been doing in order that it might see in what direction it should advance in the future, and might be able to judge whether it was really performing the duties which not merely its members but the public expect, and have a right to expect, from a society of that kind. After referring to the satisfactory financial position of the society he asked them to consider what were the claims which that society had upon its members, and upon the support and approval of the general public outside its own circle. The society was founded in 1837, and had therefore been in existence nearly 50 years. Its original purpose was not precisely that which it now pursued, though it was strictly connected with it; for he found that its original purpose when founded was described to be "to assist coal proprietors and workers in collecting and recording geological and mechanical information with the accuracy and minuteness necessary for the successful prosecution of mining." The objects then contemplated had, as they all knew, been largely superseded, since that time by the work of the Geological Survey, and that being the case, the society had assumed less of an industrial character specially connected with mining, and taken up more of a general scientific position. But he did not think that change was in any way to be regretted, because he was quite sure that there was ample work for the society in its present form. It now brought together from time to time geologists and others for the purpose of reading and discussing original papers, and it tended in that way, and by the investigation which it encouraged among its members, to the advancement of geological knowledge, and especially, of course, of a knowledge of the geology of their own county, and it encouraged the publication of papers, and it appeared to him that in doing that it was doing a very important work in the promotion of science in Yorkshire, and indeed not in Yorkshire only, but throughout the country, while it promoted habits of careful observation, which lay at the root of scientific progress. They

would remember that in quoting the words connected with the original foundation of the society, he had pointed out that it was stated that one of its objects was "to collect and record information with the accuracy and minuteness necessary for the successful prosecution of mining." They had not so much to do now with the prosecution of mining, but he hoped they were not at all forgetful that it was their duty to collect and record information with accuracy and minuteness. It seemed to him that therein lay one of the most important objects that a society of that kind could keep in view. It should encourage students to methodise their studies by publishing the results of their original research, because he thought that all present—who were greater authorities upon science than he professed to be—would agree with him that there was nothing more important in the work of scientific men, and especially the younger students of science, than that exactness and accuracy of work which resulted from a constant appeal to the test of publication and discussion. That was what that society tended to do. Nothing could be of greater value than correctness of observation and carefulness in reporting what is observed and this habit was greatly promoted; when the result of such enquiries were brought, as it were, to the test of cross-examination by competent men. That seemed to him to be one of the most important and valuable functions of a society of that kind. Their members were perhaps not very likely in these days to make any wonderful discoveries or to be able to make science take one of those great leaps or bounds forward which have occasionally resulted in the past from some profound investigation. But all who had time and knowledge to devote to scientific enquiries could help forward the general progress of science in the country by correct and careful investigation. Especially did it appear to him that that was of the first importance in relation to young students of any branch of science, whether during the course of their college life or after its termination, and when they had entered upon the duties which fell to their lot in the profession or position of life in which they might be placed. Therefore, he had learned with great pleasure that in addition to the paper which he alluded to as having been read by Mr. Whiteley, at Har-

rogate, another gentleman of the name of Mr. Easterfield, also a student of the Yorkshire College, had also read a paper at one of the meetings of that society. He wished to take that opportunity of urging strongly upon other students of that college and similar institutions to follow the example of those gentlemen, and thus do something to establish what he would like to see, a recognised connection between the Yorkshire College, and other institutions of that kind, and that society. He assured those present that all connected with the Yorkshire College at Leeds were specially anxious to make it what its name implies, a college for Yorkshire, and one of the modes of doing that was to bring it into as close union as they could with other institutions in the county having educational objects in view, and it was upon that account that he had learned with so much satisfaction that those two gentlemen whose names he had mentioned had set what seemed to him a very good example to their fellow students, and had done much to promote a connection between that and similar societies, and the Yorkshire College, from which he believed all parties were likely to derive considerable benefit. He would not detain them longer, but in conclusion he assured them that meetings of that kind could not fail to be productive of much good if it was the constant endeavour of each member to submit to the society the records of personal and original observation, investigation, and study, constantly bearing in mind that every new fact, however apparently insignificant, provided it was a real and tested fact, had a substantial scientific value, and that it might, however small it might at first appear to be, nevertheless contain within it the germ of some wide-reaching discovery of no small scientific importance, rich with new fruits of theory and of practice.

NOTES ON THE POLYZOA AND FORAMINIFERA OF THE CAMBRIDGE GREENSAND. (COPROLITE BEDS OF BRITISH AUTHORS. CENOMANIEN (?) FOREIGN AUTHORS). BY GEORGE ROBERT VINE.

The Polyzoa of the British Neocomian rocks are a peculiar group of fossils. Many of them appear to be related to species described by Goldfuss, D'Orbigny, and Hagenow, and are referred to as such in the works of Morris, Phillips, and others. The existing material, however, has only been partially worked, and the references given cannot always be accurately verified when the British specimens are compared with the foreign forms of a similar horizon. The same remarks will apply to species in the Upper Greensand of Warminster as well as other Greensand localities. On the other hand, much of the material that passed through the hands of Mr. Lonsdale seems to have been fairly described and well illustrated.* Mantell also describes—rather poorly though—a few Chalk Polyzoa in his various works, but since then much good material has been accumulating in the cabinets of collectors, and the whole of this early work may be consistently re-edited. In my fourth British Association Report on Fossil Polyzoa, 1883, I gave a resumè of what had been done by different authors; described new, and some apparently well-known Cretaceous Polyzoa; and to the best of my ability, furnished special details of all the forms that I had access to, or that were in my own cabinet. At the time I wrote Greensand Polyzoa of the Cambridge horizon were not known to exist, and it was only after the publication of my paper—" Notes on some Cretaceous Lichenoporidæ (Quart. Jour. Geol. Soc., Nov., 1884)—that the species forming the subject of the present Memoir were brought to light. There is no mention of Cambridge Greensand Polyzoa in the Cretaceous catalogue of the School of Mines, neither are Bryozoa or Polyzoa referred to in the elaborate lists of Cambridge fossils appended to Mr. A. J. Jukes-Brown's paper

* Dixon's Geology of Sussex, Plates xviii., xviii. *a*, xviii. *b*.

on the Cambridge Greensand (Quart. Jour. Geol. Soc., Vol. 31, pp. 305-313), and the same remarks will apply to the Supplementary Notes of the same author (Op. cit., Vol. 33, pp. 485-504). As these lists were compiled from Phillips' Geology of Oxford, the Memoirs of the Geological Survey of the Cambridge district, and from the Catalogue of Collections in the Woodwardian Museum, it is only fair to suppose that no Cambridge Greensand Polyzoa was, at the time they wrote, known to these respected authors.

When I wrote the paper already referred to (Cret. Lichenoporidæ), I was entirely ignorant of the positive horizon of the species described as *Lichenopora paucipora*, Vine. Immediately after the publication, Mr. Thomas Jesson, F.G.S., wrote me a kind letter respecting the fossils, and told me that he had sent the forms to Professor P. Martin Duncan, F.R.S., about two years previously, and that in all probability Professor Duncan had mislaid his letter respecting them. In addition to supplying me with the locality of the fossils, he offered to place the whole of his Cambridge Greensand Polyzoa in my hands if I would work them out. The conditions of Mr. Jesson I accepted, and in a paper laid before the Geological Society many details of this unique collection were given, both of the Polyzoa and of the Foraminifera. In all probability the whole of this paper will not be published, and I believe the paragraphs, with a list of species described, are all that will be published in the Journal of the Society (See Abstracts of the Proceedings of the Geological Society, No. 470, pp. 73-74). When asked by Mr. Davis to furnish another Palæontological paper to be read before the Yorkshire Geological Society, and for publication in the yearly Proceedings, I promised one on the Cambridge Greensand Polyzoa and Foraminifera, if acceptable. This has been acceeded to, and I am glad that Mr Jesson's material is again brought before students of British Fossil Polyzoa. As a matter of course I have adhered to my former identifications, except in a few instances. These are referred to in the text, and the alterations or additions are made after mature consideration and still further acquaintance with the subject.

The collection of Mr. Jesson is a most important one, and its description will help to fill up a blank in the hitherto published lists.

The Greensand Polyzoa of the Continent has been studied and well described by foreign authors—Hagenow, Roemer, Reuss and Novak—but owing to the scarcity of material in England very little attempt has been made by specialists to search for and describe other than the older and well-known forms of Farringdon and Warminster. The species of these two horizons have a peculiar facies of their own—but the facies of the Cambridge Greensand Polyzoa are altogether distinct, and in my identifications I have been able to correlate but few of the fossils now described with forms previously known.

It will be noticed in my descriptions that I have not given in any case the habitat of the forms. The fault, however, is not mine for the whole of the specimens—excepting the *Webbina* among the Foraminifera—were free, or unattached to any matrix. In some few instances I have been able to supply this very desirable information, for Mr. Jesson, with his usual kindness, went over the whole of his large collection of Cambridge Greensand fossils for the express purpose of selecting those which were encrusted, or had the least indication of Polyzoa being attached to them, and out of a collection sent to me of about fifty or more specimens I have been able to select a few that had been habitats of the once living colonial mass. This data will be valuable to future collectors, and may help to bring to light other species from the Cambridge horizon.

LIST OF FOSSILS FURNISHED FOR OBSERVATION.

1. Ostrea cunabula, Seeley.	Polyzoa, *Diastopora Sp.*
2. Pharetospongia strahani, Sollas.	Polyzoa, but indistinct.
3. ,, ,, ,,	*Diastopora fecunda*, Vine.
4. Radiolites Mortoni, Mantell.	*Diastopora* and *Membranipora Sp.*
5. Ostræ sp.; attached to *Radioletes*.	*Diastopora fecunda*, Vine.

The above are selected from a list of specimens from the Cambridge beds numbered 1 to 24. Most of the other specimens have encrustations, *Webbina*, &c., but no distinct traces of Polyzoa.

The species of Polyzoa and Foraminifera now described are as follows:—

Sub-Order CYCLOSTOMATA, Busk.

1. Stomatopora gracilis, Milne Edwards.
2. Idmonea dorsata, Hagenow.
3. Entalophora raripora, D'Orbigny.
4. „ Jessonii, Vine (now limited).
5. „ striatopora, Vine.
6. „ neocominensis D'Orb. (Waters).
7. „ gigantopora, Vine.
8. Diastopora cretacea, Vine.
9. „ „ Var. lineata, Vine.
10. „ fecunda, Vine.
11. „ megalopora, Vine.
12. „ confluens, Reuss (Novak).
13. Lichenopora ? paucipora, Vine.
14. „ radiata Aud, or variety of same.
15. Domopora polytaxsis (?), Hagenow,
16. Truncatula sp. (? T. repens, Hagenow).
17. Osculipora plebeia, Novak.

Sub-Order CHEILOSTOMATA, Busk.

18. Membranipora Dumerilii, Aud.
    var cantabrigensis, Vine = *M. cantabrigensis*, Vine.
19. Microporella sp. (? antiquata).
20. Lunularia cretacea, Defrance.

FORAMINIFERA.

21. Webbina tuberculata, Sollas.
22. „ lævis, Sollas.
23. Trochammini helveto-jurassica, Hausler = *T. irregularis* (?) D'Orb., Vine
    ? Haplophragmium sp., Reuss.
24. Textularia agglutinans, D'Orb. = *Textularia sp.*, Vine.

Part 1. POLYZOA.

Sub-Order, CYCLOSTOMATA, Busk, Hincks, &c.

Brit. Mus. Cat., part III.: Brit. Mar. Polyzoa, Vol. 1.

Family TUBULIPORIDÆ.

1875. Busk, British Mus. Catalogue, pt. III., p. 23.
1880. Hincks, British Marine Polyzoa, Vol. I., p. 424.

(For Synonyms, &c., see above works).

1.—STOMATOPORA GRACILIS, Milne Edw. (?) plate II., fig. 7.

= *Alecto gracilis*, Lonsdale, Dixon's Geo. Sussex, pl. XVIII.

= *Stomatopora gracilis*, Vine, Brit. Assoc. Report, Fossil Polyzoa, 1883.

Zoarium wholly adnate, branches liner, delicate, rarely, if ever

anastomosing. *Zoœcia* (generally) in a single series, thick and occasionally bulging at the nodes,* orifice circular, with a thin peristome. *Oœcia* an inflated cell with orifice depressed.

Range of variation.—This species varies very much in the cretaceous rocks; the Greensand forms, generally speaking, differ from those found in the Upper Chalk, but chiefly in the length and delicacy of the cells. There is only one poor specimen in Mr. Jesson's collection, and by careful manipulation I have been able to give a figure of the species which I can only regard as the same, or at the most, a variety of the Upper Chalk *S. gracilis.*

Localities: Cambridge, Greensand; Upper Greensand, Warminster; Upper Chalk, Wilts (Phillips); Beachy Head (Miss Jelly); Norwich, Sutton (Morris' Catalogue Brit. Foss.)

2.—IDMONEA DORSATA, Hagenow.

Idmonea dorsata Hagenow, Bry. der. Müs. tr. Kreid. form.

= *Retepora disticha* (pt.) Golf. Petrefac. pl. IX., fig. 15. *g. and h.*

There is only a single fragment of an Idmonæ in Mr. Jesson's collection. It is similar to the form which Hagenow gives as the type of his *I. dorsata*, but rather more delicate. The species is common in the Faxœ Limestone of Denmark.

Localities: Cambridge, Greensand; Upper Chalk Mæstricht beds; Faxœ Limestone Denmark (Vine).

3.—ENTALOPHORA RARIPORA D'Orb., Plate I., figs. 1 and 2.

1850. *Entalophora raripora* D'Orb., Prodr. Pal. Strat. p. 267; Pal. Franc., p. 787, pla. 621, figs. 1-3; pl. 623, figs. 15-17; Beissel. Bry. Auchener Kreidebildung. p. 82, pl. X., figs. 120-128; Novak (part) Beitr. z. Kenntn. d. Bry. der Bohm. Kreide., p. 32. (So Waters.)

1851. *Pustulopora virgula* F. Hagenow, Bry. Mästr. p. 17, pl. 1, fig. 3.

1883. *Entalophora incerta* Vine, Brit. Assoc. Rep. Foss. Pol. (For other Synonyms see Novak. Beitr. z. Kenntn. d. Bry. der. Bohm. Kreid., p. 32; A. W. Waters, Foss. Cyclostomatous Bry. Australia Quart. Jour., Geo. Soc., Vol. 40, p. 686.)

Zoarium delicate or robust, erect and ramose, branches variable, ranging from subcylindical to cylindrical, bulging at the nodes. *Zoœcia* tubular elongated, or depressed, partially decumbent, occasionally produced towards the distal extremity, opening on all sides; cells

* I have used the word 'node' to indicate the part just below the branching of the cells.

punctured (?) Oœcium an inflation of the Zoarium, or an inflated cell.

Range of variation.—The range of variation of this species may be estimated if reference be made either to the synonymy of Novak, or to that of Mr. A. W. Waters. There is, however, a great difference in the list of the two authors, and I have reproduced only those names that I could verify in British Cretaceous rocks after the full reference given from D'Orbigny. The Greensand form differs from specimens of what we may reasonably consider the same species in the Upper Chalk, but I am not able to verify the whole of Novak's references. The *Pustulopora rustica*, and *P. nana* Hagenow in my Faxœ Limestone material are altogether different from those of the British Cretaceous, *E. raripora.*

Localities: Cambridge, Greensand fairly abundant; Chalk detritus Kent; Faxœ Limestone Denmark; Palaski Co. Arkansas (Cretaceous Rocks, America.) All in my own cabinet. Mr. Waters gives a long list of localities European and Australian.

4.—ENTALOPHORA JESSONII, sp. nov. Plate I., fig. 6.

Zoarium cyclindrical (normal), occasionally flattened by compression; branches variable—in young specimens rarely exceeding two millimetres in breadth, thicker and more bulky in older specimens—bifurcating, but thick immediately beneath the separation. *Zoœcia* irregular, or disposed in spirals, orifice circular, or slightly oval, peristome thick; cells tubular, stunted, or elongated, occasionally bordered by divisional, hexagonal lines in older specimens.

Range of variation.—The occasional bordering of the cells by divisional lines gives to older and worn specimens of this species a peculiar *Eschariform* character, but the range of variation is more noticable in the older, than in the younger forms. This, and the next species are very characteristic of the Cambridge material.

Locality: Cambridge, Greensand.

5.—ENTALOPHORA STRIATOPORA, sp. nov. Plate I., fig. 5.

Zoarium originating from a broad disk-like base, branches bifurcating or irregularly disposed. *Zoœcia* tubular, distal extremity produced, proximal, generally immersed; the whole of the intervening space between the cells covered with longitudinal or zigzag striæ. *Orifice* circular, peristome thick and prominent.

Range of variation.—This is chiefly noticable in the young, and in the older forms. In the young forms the striæ are regularly disposed in longitudinal ridges, over and around the cells; in the older forms the striæ become densely fenestrated, and the basal portion of the stem is covered with a thick coating of calcareous matter which entirely obscures the earlier cells. The disk-like base and the early portion of the stem of this species is most peculiar, and I have not the least doubt but that some of the forms of *Osculipora plebeia* —presently to be referred to—may be regarded as only the basal portion of the stem of *E. striatopora.*

Locality: Cambridge, Greensand.

6.—ENTALOPHORA NEOCOMINENSIS, (?) D'Orb. Plate I., fig. 4.

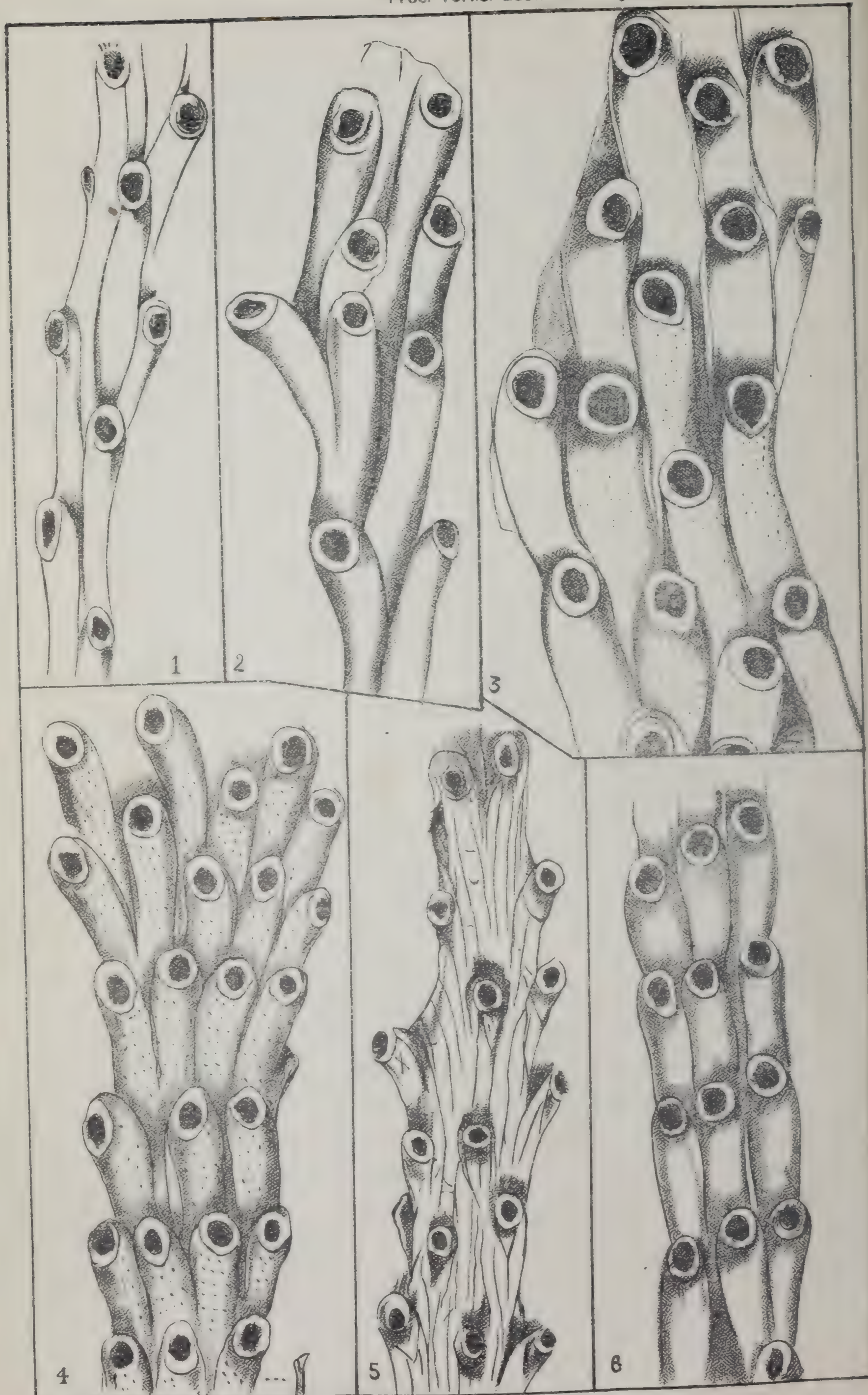
Entalophora id., D'Orb., Pal. Fr., p. 782, pl. 616, figs. 15-18.

Spiropora pulchella, Rss. Foss. Anth. u. Bry. von Crosara, pl. XXXVI., figs. 4-5.

Cricopora id., Rss. Poly. p. Wien., p. 40., pl. VI., fig. 10.

Entalophora neocominensis, Waters, Quart. Jour. Geo. Soc., Vol. 40, pp. 686-687. (Mr. Waters gives other synonyms.)

There is a strange specific likeness in all the forms of this peculiar group of Fossil Polyzoa and I hesitated for a long time before placing the Greensand form here. It matters not whether we describe forms from the Lias, Jurassic, Cretaceous or Tertiary rocks, there is a possibility of confounding the various forms, if not carefully compared. In following Mr. Waters in his identifications, I do so on consideration of his placing the *Spiropora pulchella* Rss. in the group. This form I have carefully studied from specimens which were originally in Reuss's collection, and I can fully endorse the testimony of Mr. Waters as to the difficulty of separating the supposed synonymous forms. It must, however, be borne in mind that there are still difficulties in the way of fully accepting the whole of the synonymy. In *Spiropora pulchella* Rss. the cells are more closely packed in the branch than in the Greensand form—the orifices of the cells are smaller—and in some of the cells the lower lip of the peristome is very peculiar. Then again, *Entalophora* (Spiropora) *pulchella* Rss. is given by Novak, as a synonym of *E. geinitzi* Rss. on the other hand the puncturing of the cells in the Greensand form



GREENSAND POLYZOA.

is similiar to the puncturing of the *E. pulchella* Rss. from the Montecchio Maggiori (Tertiary) deposits of North Italy. Under present circumstances I only give one locality from my own observation, and refer the reader to Waters and to Novak for others.

Locality: Cambridge, Greensand. Waters: Valangien St. Croix and Pontarlier (Jura): Miocene: Austria and Hungary, and Crosaro, Val di Lonti (Rss.); Orakei Bay (Stal) Curdies Creek, Mt. Gambier, Bairnsdale and Muddy Creek, Australia (A. W. W.)

7.—ENTALOPHORA GIGANTOPORA sp. nov. Plate I, fig. 3.

Zoarium compressd, rarely rounded. *Zoœcial* tubes either wholly immersed or slightly raised above the general surface of the Zoarium; divisional wall of the cells faintly outlined, orifice large, circular with very thick peristome. Surface of cells finely punctured.

Locality: Cambridge, Greensand.

Remarks: This species is of such large dimensions as regards the cells that it might easily be mistaken for a member of an altogether different group of Polyzoa. I think, however, that I am perfectly justified in placing it with the Entalophoræ, but my reasons for doing so may be briefly stated: The cells though large, or apparently abnormal, have no secondary characters, such as ovicells or avicularia to assist the judgment in placing it differently, neither are the two surfaces of the Zoarium separated as in ordinary Eschariform species, yet I am unacquainted with any Polyzon with which the present species can be compared.*

Descriptions. Plate I., figs. 1-6.

All the Entalophoræ of this plate are drawn to one scale, magnified about 33 diameters.

Fig. 1. Entalophora raripora, D'Orb. A very young form of the species.

Fig. 2. ,, raripora D'Orb. Though a rather old specimen, I have been able to trace the connection between this and younger forms.

* Since this was written I have received from France specimens of Polyzoa (Bryozoa) from the Cenomanean Strata Mans. There is one species, *Vincularia cenomana* D'Orb., that 'facially' may be partially confounded with the present form, but the student by closer scrutiny will soon detect a great difference in the two types.

Fig. 3. Entalophora gigantopora, Vine—an ordinary but characteristic specimen.
Fig. 4. „ neocominensis, D'Orb. (now separated from *E. Jessoni.*)
Eig. 5. „ striatopora, Vine.
Fig. 6. „ Jessoni, Vine.

8.—DIASTOPORA CRETACEA, Vine.

Diastopora cretacea (n. sp ?) Vine, Brit. Assoc. Report, Fossil Polyzoa, 1883.

Zoarium adherent, with a nearly circular outline, depressed in the central part, very much thickened at the edges by stunted (partially grown) cells, but without basal lamina. *Zoœcia* irregularly arranged, contracted towards the proximal and thickened at the distal extremities, separated by interspaces; orifice circular with a thickened peristone. *Oœcia* an inflated cell.

Localities: Cambridge, Greensand; Upper Chalk, Sussex (Miss E. C. Jelly.)

This species is represented in Mr. Jesson's collection by a single example, and this seems to have been derived from the Cretaceous rocks above. The specimen is rather more water-worn than ordinary examples of Polyzoa from the Cambridge Greensand horizon.

9.—DIASTOPORA CRETACEA, Vine. Var. LINEATA var. nov., Pl. 2, fig. 8.

Zoarium adnate, with a circular or semi-circular outline. *Zoœcia* linear, but rarely more than three or four in the series, the last cell originating a new lineal departure until the edge of the Zoarium is reached; primary cells irregular, central. *Oœcia ?*

Locality: Cambridge, Greensand.

10.—DIASTOPORA FECUNDA (sp. nov.)

Zoarium variable, either flat and circular, or dome shape, proliferous; basal colony, or disk about eight or nine millemetres in diameter, overlaid by another colony rather less in diameter, and then by others still decreasing in size. *Zoœcia* variable, elongated but rarely exposed, except at the distal extremity of the cell; orifice circular (normal), or slightly elongated (worn), peristome thin, not

prominent, cells not wholly contiguous, sparsely punctured. *Oœcia* an inflated cell (?)

Locality: Cambridge, Greensand.

This is by far the most abundant of the whole of the Diastoporæ of the Jesson collection. Before deciding to characterise this and the following species as new, I examined a large series of British specimens of Oolitic and Cretaceous *Diastopora*, but I could not find that any of these possessed similar facial characteristics; then again every available figure of foreign Greensand species was examined with like results, and although Novak figures several species of *Berenicea* I could only identify one of the Cambridge species as referable to forms described by the author. In a semi-transparent section of *D. fecunda* which I have prepared, the peculiar structural features of the species are very apparent. The super-imposed colonies originate from marginal cells, and the initial stages of a new colony is flabellate and ultimately disciform, the new colony entirely obliterating or covering up the original.

11.—DIASTOPORA MEGALOPORA sp. nov. Plate II., figs. 9 to 9*e*.

Zoarium circular or nearly so, far more robust than *D. fecunda*, but proliferous. *Zoœcia* short, or stunted; primary cells centric, fully exposed, but the surrounding cells which are wide apart, either wholly immersed or only partially exposed; orifice circular, peristome thick, occasionally raised. *Oœcia* an inflated cell (9 *b*.) or an inflation of the Zoarium involving two or three cells (9 *a*).

Locality: Cambridge, Greensand.

12.—DIASTOPORA CONFLUENS Reuss.

= *Berenicea confluens*, Novak, Beit. z. Kennt. Bryoz. der. Böhm. Kreid., p. 99, Part IV., figs. 19-22.

(Novak gives several synonyms.)

There are a few specimens of *Diastopora* in the collection that may be referred to this species as described by Novak, only that the cells are not altogether of the same shape as those figured by the author. All the cells are contiguous (confluent) and beautifully punctured. In section no inter-spaces are apparent. It appears to be allied to Novak's species if not identical. Colonies circular—proliferous.

Locality: Cambridge, Greensand.

Family LICHENOPORIDÆ, Smitt.

Hincks, Brit. Marine Polyzoa, Vol. I., p. 471, 1880.

= *Caveidæ* (part) D'Orbigny.

= *Discoporellidæ*, Busk. Brit. Mus. Catalogue, part III., 1875.

13.—LICHENOPORA? PAUCIPORA, Vine.

= *Lichenopora paucipora*, Vine, Quart. Jour. Geol. Soc., Nov. 1884. (with figure) p. 853; Ibid (op. cit.) May, 1885—Note p. 113.

This peculiar species, was represented by several specimens in Mr. Jesson's original collection, but specimens were sent by him to Prof. Duncan for identification, as Mr. Jesson supposed them to be allied to the Corals, if not new types of the group. Prof. Duncan handed them over to Mr. George Busk and ultimately the specimens passed from his cabinet to mine. When I described the forms I was entirely ignorant of the locality whence they were derived. After the publication of my paper Mr. Jesson wrote me respecting the specimens, &c. When sketching out my original description I knew of no group, recent or Fossil, in which they could be placed. except among the Lichenoporidæ, and as only two Genera are given by Mr. Hincks—*Lichenopora* and *Domopora*, I prefered to present it as a member of the first, rather than of the second genus. After the publication of my notes Mr. A. W. Waters expressed to me his doubts respecting the placement of the form amongst ordinary *Lichenopora*, and out of deference to him I have placed (?) after the generic term. It is very evident that the specimen described is remarkable, both on account of its peculiar stipitate column and disk-like capitulum, and I have not been able to find in the writings or figures of Goldfuss, Hagenow, Rœmer or Novak any indications of forms similar in character, either among the Greensand or Upper Chalk Polyzoa.

Locality: Cambridge, Greensand.

14.—LICHENOPORA RADIATA (?) Audouin (or variety of same.)

Discoporella id. Busk. Brit. Mus. Cat. pl. III., p. 32. Plate XXXIV., fig. 3. (Non. Hincks. Brit. Mar. Polyzoa, pl. LXVII., fig. 9.)

There are a few specimens of a species of *Lichenopora*, of the *Discoporella* type in the Jesson collection, but these are more like Busk's figure than Hincks'.

Zoarium obicular, centre depressed, cancelli small and sparse. *Zoœcia* disposed in rays, and alternately long and short, but the rays rarely exceed twelve in number.

Locality: Cambridge, Greensand.

Apparently the single row of pores between the rows of cells are present in the Greensand specimen which I am describing, but these are partially overgrown by an incrustation of calcareous matter, imbedded in which is a small *Spirorbis*.

Genus DOMOPORA, D'Orb.

Zoarium massive, cyclindrical or mammiform, simple or lobed, formed of a number of sub-colonies super-imposed one upon the other; the whole surface porous. *Zoœcia* dispose in radiating lines, consisting of one or more series, on the free extremity of the stem or lobes. (Hincks, Brit. Mar. Polyzoa, Vol. I., p. 481.)

15.—DOMOPORA POLYTAXIS (?) Hagenow.

= *Ceriopora id.* Hagenow, Die Bryoz. der Maas. tr. Kreid, Tab. V., fig. 2.

There are several specimens in the Cambridge Greensand material that I refer—but still with a doubt—to this species. The fragments are similar to those which I have from the Faxœ limestone, but the characters are not quite so well marked. One specimen that I formerly referred to Goldfuss' *D. stellata*, I have withdrawn after due consideration and comparing with the original figure in the Petrifacta as I think now that that was a wrong identification.

Localities: Cambridge, Greensand; Faxœ Limestone, Denmark.

There are three species in my Cenomanien series that will afford ample material for special study of the Domoporæ of the Cretaceous rocks, especially so in connection with the Upper and Lower Chalk, and Greensand and Neocomian forms. These are *Pelagia insignis* Michelin; *P. Eudesii*, Mich.; and *Domopora clavula*, D'Orb.; none of which are related to British Cretaceous species.

Family FRONDIPORIDÆ, Busk.

Zoarium massive, stipitate, simple or lobed, or ramose, Cells

connate, aggregated into fasciculi, and continuous throughout the length of the fasciculus, at the extremity of which only they open; wall of cells porous; no intermediate pores or cancelli. Busk. Brit. Mus. Cat., pt. III., Cyclostomata, p. 37.

The family are represented by two Genera.

16.—TRUNCATULA sp. (T. repens ? Hag. d. Bryoz. Kreid., pl. III., fig. 1.)

Truncatula Hagenow (*Idmonea* sp. of authors.)

Only one poor specimen of this genus was found in the Jesson material.

Localities: Cambridge, Greensand; Faxœ Limestone; Maestricht, Falkenberg (Hagenow.)

The following peculiar Genus has been founded by D'Orbigny for the placement of Fossils called by Michelin *Pelagia* and *Idmonea* (*I. aculeata* Mich.) Novak has adopted the Genus for his work on the Bryozoa of the Bohemian Cretaceous series, and the British forms are related to his, rather than to D'Orbigny's *Osculipora.*

Genus OSCULIPORA, D'Orb.

17.—OSCULIPORA PLEBIA, Novak. Beit. z. Kennt. der Bryoz. der Böhm. Kried. p. 112, Tab. X. f. 16-34.

Forms, evidently belonging to this species, are very abundant in the Cambridge material. These are generally found as simple, and much branched. While some few of the specimens in the Jesson collection may be referred to as the bases of species of Entalophoræ, others are undoubtedly species of the Frondiporidæ of Busk, and *Osculipora* may be related to *Fasciculipora* if not a true member of the Genus. Fasciculæ few in number.

Sub-Order, CHEILOSTOMATA, Busk.

See Brit. Mus Cat., pts. I. and II.; the Monograph of the Polyzoa of the Crag (Busk)—British Marine Polyzoa, Vol. I., Hincks; and the six Reports on Fossil Polyzoa (mihi), British Association, 1880 to 1885, for special details of Recent and Fossil Polyzoa.

Family MEMBRAMPORIDÆ, Busk.

Brit. Mus. Cat., pt. I., Busk; Crag Polyzoa, Busk; Brit. Marine Polyzoa, Hincks; Challenger Reports, Polyzoa, Busk.

18.—MEMBRANIPORA DUMERILII, Aud. (Hincks Brit. Mar. Pol., p. 156) var. CANTABRIGENSIS n. var. Pl. II., fig. 10.

Zoœcia, small ovate, or irregular in outline, three cells measure about three millimetres, occasionally rather more or rather less margins sloping inwards, smooth (?) or with faint indications of the former existence of spines. *Oœcia*, globose. *Avicularium*, large pointed, on one or both sides of the ovicell, and occasionally between other cells as well. Cells separated by interspaces.

Locality: Cambridge, Greensand.

I have hesitated considerably before giving the above name to this Greensand species, and I do so now on account of the peculiarity of the ovicell and the placement of the lateral avicularium. The form, however, is more closely related to Mr. Busk's figure of *M. Pouilletii* (Crag. Pol., Fig 6, Pl. III.), than to Mr. Hincks' (Fig. 3, Pl. XX., Brit. Mar. Pol.), and it differs from both in the way in which the cells are separated, and the comparative scantiness of the ovicells. Avicularia are very freely distributed between the cells in the colony, but there is generally one avicularium on either side of the oæcium, but rather longer and more pointed than those figured either by Mr Busk or by Mr. Hincks. There are slight variations in the form of the cell but its characteristic features are similar to the Crag form, but not so distinguishable as the recent; yet, even in this Mr. Hincks says, "There are slight diversities in the shape of the cell: but in its prevalent and characteristic state it is contracted at the top and broad below. The ovicell is often much produced: but it also assumes a more rounded form."

I have compared the specimens—which are rather abundant in the Cambridge material—with the figures of *Membranipora* in the works of Hagenow and Novak, none of which are sufficiently characteristic for the placement of the present species. The nearest approach to the Greensand form is given by Manzoni (Castrocaro, Pl. II., Fig. 21) as *M. Flemingii*, Busk, only that the ovicells and avicularia are smaller; *M. Flemingii*, Busk (Brit. Mus. Cat., pl. CIV., fig. 2) is a synonym of *M. Dumerilii* (Hincks).

Family MICROPORELLIDÆ, Hincks.

British Marine Polyzoa, Vol. I., p. 204: Challenger Reports, Polyzoa, Busk. (pars.)

19.—MICROPORELLA sp. (? ANTIQUATA). Pl. II., fig. 11.

Zoarium, encrusting. *Zoœcia*, marginate, aperture semi-circular, lower lip entire, with a circular umbo (pore ?) below.

Locality: Cambridge, Greensand.

There is in Mr. Jesson's collection a single colony, of only a few cells, of a species of *Microporella* (?) that I cannot identify in any published figures known to me. The cells are marginate, similar in some respects to *Flustramorpha marginata*, Busk (Challenger Report, pl. XX., fig. 8), but the cell mouth is different, and beneath the lower lip is either a small tubercle or a circular pore, and as this is only well shown on the surface of one cell no comparison can be instituted. The cells are one millemetre in length, and the colony is 7 mm. long, and 2 mm. broad.

Family SELENARIIDÆ, Busk, 1853.

Only two Genera are placed by Busk in this family *Cupularia* Lamx., and *Lunulites* Lamx., and besides giving a very fair description of the generic and specific characters of the Crag species, a rather full list of all known species is furnished by the author.*

The family is represented by only one Genus—*Lunulites*—in the Cambridge Greensand collection, and by only one species of the Genus.

Genus LUNULARIA, Lamoroux.

Busk, Monograph of the Challenger Polyzoa (Cheilostomata) 1884. = *Lunulities* Lamx. Busk and other authors generally. *Zoœcia* disposed in series, radiating from the centre and bifurcating as they advance towards the border; the vibracula lying in linear series, alternating with those of the *Zoœcia*. The chitinous vibraculum usually bifid, or trifid at the extremity. Busk, Challenger Monogr. (op. cit.) p. 208.

20.—LUNULARIA CRETACEA, Defrance.

=*Lunulites cretacea* Defrance, D'Orbigny.

The specimens which I place here are not numerous in the

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* Monograph of the Crag Polyzoa, pp. 78-89.

Cambridge Greensand collection, but they are found both free, and adherent to foreign bodies. The species, wherever it may be ultimately placed, is the same as ordinary cretaceous forms—and identical with those found in the Upper Greensand of Warminster.

The specimens are both large and small.

Zoarium both encrusting and free—dome shape, with cells, radiating from the centre, but the other characters, if present, are too indistinct for diàgnostic purposes.

Localities: Cambridge, Greensand.

I do not think that the above species could be confounded with the *Lunulites urceolatus* Lamx., of Lonsdale. (Dixon's Geo. of Sussex, Tab. 1., figs. 8 *a*, *b*, *c*.) Morris in his Catalogue of Brit. Fossils gives *L. urceolata*, and *L. radiatas* Mant., as synonyms, also Lonsdale quotes Goldfuss' fig. (Petrefac. Tab. 12, fig. 7,) and this Busk regards as a synonym of *L. conica* Defrance Var. a. *depressa*. (Crag, Polyzoa, p. 88.)

Part II., FORAMINIFERA.

Division *A. Imperforata.*

Notes of Reticularian Rhizopoda, &c., H. B. Brady, Quart. Jour. Micro. Soc., Vol. XXII., New Ser.

Catalogue of Fossil Foraminifera, Brit. Mus., Prof. T. Rupert Jones, F.R.S., 1882.

Sub-division III., ARENACEA.

Group III., Test Calcareous and Arenaceous.

Family IV., LITUOLIDÆ (Jones Cat. op. cit. page X.)

Genus WEBBINA, D'Orb.

Prof. W. J. Sollas, Geological Mag.—1877, p. 103.

Test consisting of a single more or less hemispherical, ovoidal, or pyriform chamber terminated in many cases by a short narrow open tubular prolongation, or a succession of such chambers in variable numbers, connected together in a moniliform series, varying in direction of growth, &c.

As this genus is re-described by Mr. Sollas I have selected from his "General Characters" so much of his diagnosis as the specimens before me warranted. The forms are very abundant in

Mr. Jesson's collection, and every aspect of individual growth can be studied with perfect safety, but I am not prepared to enter into a full discussion of the minute structures given by Mr. Sollas. One remark, however, may be quoted from his paper. Speaking of the species of *Webbina*, described below, he says, "It did not occur to me to question the arenaceous character of *(Webbina)*, till in examining a thin slice of Ventriculite. . . . I observed two specimens of a foraminifera in section presenting the same outline of that of the supposed *W. irregularis*, and adherent like it to a piece of coprolite. . . . Both these sections exhibit in an unmistakable manner the tubulation of the shell-wall which distinguishes the *Vitrea perforata*. . . . And next and most important, that these *Webbinæ* are truly perforate foraminifera." Geol. Mag. loc. cit. pp. 102-103.

21.—WEBBINA TUBERCULATA, Sollas. Pl. II., fig. 14.

Sollas: Geol. Mag. 1877, p. 104, pl VI., figs. 4 to 7 and 9.

Surface of test ornamented by a number of tubercles irregularly (?) disposed, generally hemispherical and depressed, resembling rivit-heads of an iron girder.

Locality: Cambridge, Greensand.

This is a very abundant form in Mr. Jesson's material, and I can fully endorse Mr. Sollas's remarks as to the peculiar ornamentation of the surface. Occasionally the ornamentation is so regular that it is possible to count the tubercles as they are disposed in rows.

22.—WEBBINA LÆVIS, Sollas, Pl. II., fig. 13.

Sollas, Geol. Mag. (op. cit. p. 103-4.) pl. VI., figs. 1-3.

? *Trochammini* (Webbina) *irregularis* Dr. Hausler, Ann. Mag. Nat. History. Ser. 5, Vol. 10, pp. 349-337, pl. XV., fig. 15.

Surface of test smooth, not tuberculated.

Locality: Cambridge, Greensand.

In his remarks on the latter species Mr. Sollas says (loc. cit., p. 104), "As the contents of the Cambridge Greensand bed have been subjected to very considerable attrition, it is just barely possible that *W. lævis*, is simply *W. tuberculata* with its outer tubercles worn off. The smooth, beautifully finished appearance of

the former species does not lend any support to this conjecture." I believe Mr. Sollas is perfectly justified in his conjecture that the two species are distinct, only from my own observations I find that *W. lævis* is more often lagæniform than *W. tuberculata*, but I have found that both forms of tests are either *tuberculate* or free so that mere outline is no sufficient guide. Dr. R. Hausler, however, speaking of the Jurassic *Trochammini* says of *Webbinæ* (p. 353 op. cit. above) "that though present in almost every Jurassic Zone—beginning with the Lias only two or three species could be discovered" (in the zones described by him.) One of these is *Trochammina* (Webbina) *irregalaris* D'Orb., but the description given by the author is very different from the re-description of the Genus by Mr. Sollas.

Trochammini (Webbinæ) *irregularis*, D'Orb.

"Annals" (op. cit. p. 352, pl. XV., fig. 15.)

"Test thin, fragile, finely arenaceous, one or more chambered; monothalamous variety consisting of a small pyriform, or almost hemispherical chamber; polythalamous variety straight or irregularly curved . . . . . &c."

Up to the point where the description is broken off many of the smaller attached forms of the Cambridge Greensand and Jurassic agree, and even the "short stolens," are likewise present in some.

23.—Trochammini helveto-jurassica, Hausler. Pl. II., figs. 12-12*a* and 15-16.

Annals Mag. Nat. Hist. Ser. 5, Vol. 10, pl. XV., figs. 10-11.

Test coarsely arenaceous, chambers irregular—adherent in the early stages of growth, free and unattached in later stages.

Localities: Lower Malm Aargon (Hausler Jurassic); Cambridge Greensand.

This is the most abundant of the forms found in Mr. Jesson's material, and it would be quite easy, if convenient to do so, to found a number of varieties out of the abundance. But a few remarks may be advantagous. As the early adherent stages of *T. helveto-jurassica* very closely resemble *Webbinæ*, it may be possible to mistake the one for the other, only that *Webbinæ* (species described) is never coarsely arenaceous in its initial stages, and close observation would

prevent a misconception, or at least a misunderstanding of the different forms. I speak of the superficial aspect, and not of the microscopical characters given by Mr. Sollas. In fig. 12*a*, I have given a camera drawing of the external of Chamber, fig. 12, magnified about 130 times. The fragments are given as arranged by the unintelligent sarcode of the animal, the white interspaces show where the pieces have been cemented so as to form a chamber. All the rest of the chambers are similarly constructed. Fig. 15, represents one of the many varieties of this Group, but it will be observed that the last chamber is very different from that of fig. 12.—a portion of the primary chamber is broken away, but it has never been so large and prominent as the species described. Another *variety* (?)—but of which I have my doubts—is given in fig. 16, pl. II. The terminal chamber is altogether different from the ordinary run of the *Trochammini* of the Cambridge horizon, and in the third chamber from the top, there is apparently a perforated opening. It may be that this form is related to, or perhaps a member of the Genus *Haplophragmium* of Reuss (Mono. Carb. and Permian. Foraminifera) Palæont. Soc.

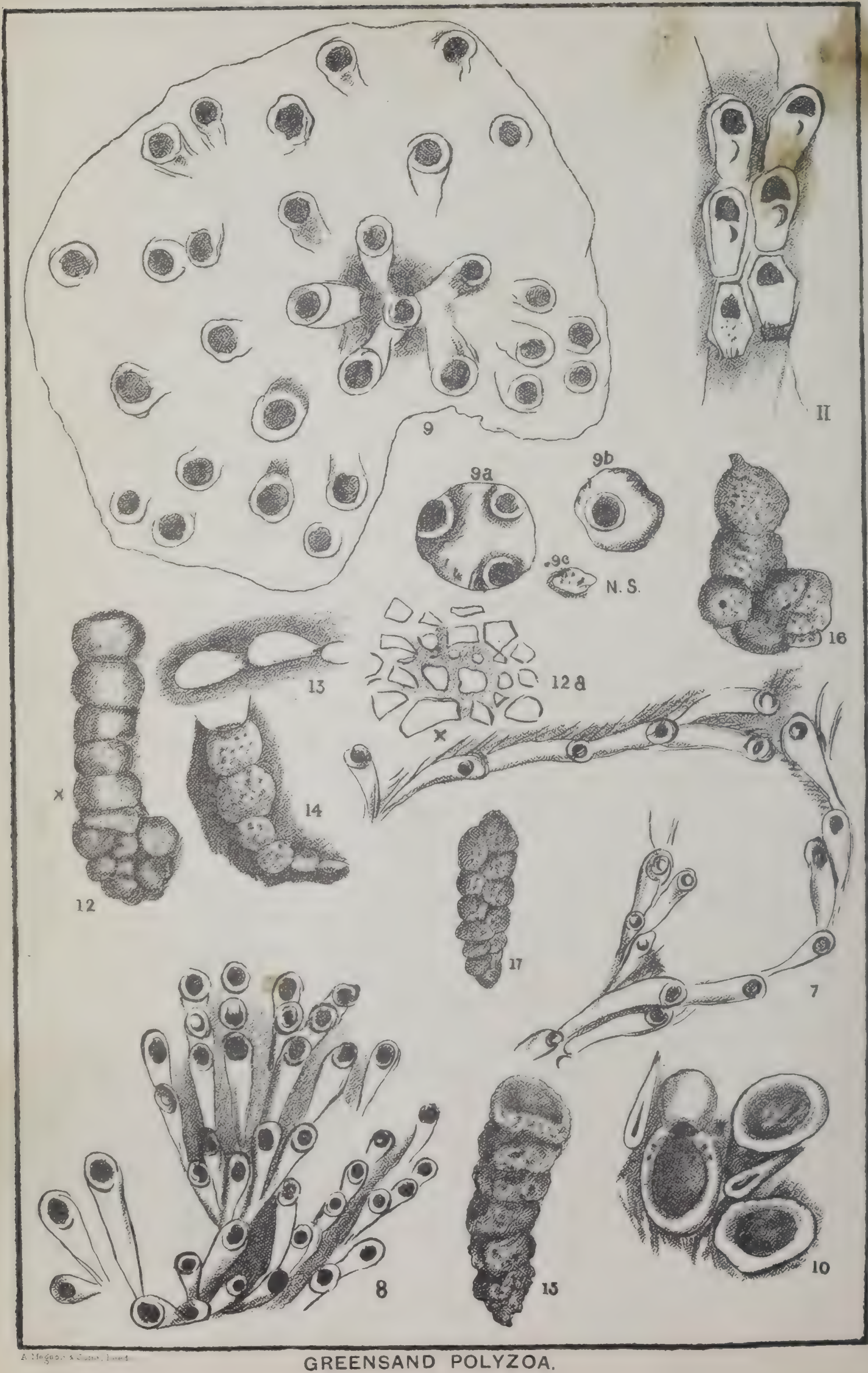
24.—TEXTULARIA AGGLUTINANS, D'Orb. Pl. II, fig. 17.

See Brit. Mus. Cat. Foraminifera (Prof. T. Rupert Jones,) pp. 26-27 and 85. Note on the Foraminifera of the Chalk, by T. Rupert Jones, F.R.S. 2nd. Edition of Dixon's Geology of Sussex, and supplementary notes Brit. Mus. Catalogue, pp. 85 to 88, wrote by Joseph Wright (op. cit. pp. 89-90.)

There is present in the Greensand material a few specimens of *Textularia* which can hardly be separated from *T. agglutinans*, D'Orb. I have figured the most characteristic of the forms.

Locality: Cambridge, Greensand.

No Foraminifera, excepting *Parkeria*, is quoted in the Cambridge Greensand list (Cat. of the School of Mines). Neither are any given in the Cenomanian series besides *Parkeria* in Prof. T. Rupert Jones' Brit. Mus. Cat., p. 9; and no mention of *Textularia* is made in the Gault lists of either the School of Mines Catalogue or in that of Prof. Jones. In the Turonian series, or Chalk Marl and Lower Chalk, several species are named, but not the above (Catalogue of Foss. Foram. Brit. Mus., 1882, p. 10).



GREENSAND POLYZOA.

Description of Plate II.

Fig. 7. Stomatopora gracilis, Milne Edwards (?) × 33 dia.

Fig. 8. Diastopora cretacea, Vine. Var. Lineata, Vine, × 33 dia.

Fig. 9. ,, megalopora, Vine. 9*a*, and 9*b*, Ovicells of another specimen, 9*c*, Natural size of Colony.

Fig. 10. Membranipora Dumerilli, Var. cantabrigensis, Vine. a few cells showing the ovicell and avicularia.

Fig. 11. Microporella (? antiquata). The most characteristic cells of the species described.

FORAMINIFERA.

Fig. 12, Trochammini helveto-jurassica, Hausler.

Fig. 12*a*, Portion of the wall of Chamber, × 130 times.

Fig. 13, Webbina lævis, Sollas.

Fig. 14, ,, tuberculata. Sollas.

Fig. 15, Variety (?) of *T. helveto-jurassica.*

Fig. 16, ,, (?) ,, ,, ,, (Haplophragmium? Reuss.)

Fig. 17, Textularia agglutinans (?) D'Orb.

The whole of the above, except 12*a*, reduced from large Camera drawings.

ON THE ORIGIN OF THE CHALK DALES OF YORKSHIRE. BY J. R. MORTIMER, F.G.S.

The great interest attaching to the formation of the Chalk Valleys has been much increased by an able Paper read by the Rev. E. M. Cole, of Wetwang, at a meeting of the Members of the Yorkshire Geological and Polytechnic Society, held at Driffield, July 2nd, 1879.*

Mr. Cole if I understand him rightly, attributed the formation of those dales to erosion subaerial, submarine and glacial. In the subsequent discussion, Mr. Dakyns of the Geological Survey,

* York. Geol. and Polyt. Society, Vol. VII., Part II., p. 128.

strongly opposed these views, and expressed his belief that they were nearly all caused by streams of running water, which, if I fully comprehended his meaning, originated at, and flowed from the upper end of each valley to lower ground and then to the sea. Though this fluviatile theory has been and is still held by some of the best Geologists of the day, it does not seem applicable to the area under consideration. The valleys themselves do not show any well marked proof of having been excavated by running water; whilst the very few existing streams now running for short distances along some of the valley bottoms, do not seem to have had any relation to such a vast number of streams as would have been required to produce the existing valleys. Moreover there is no evidence that one of these dales has ever been deepened, or eaten back since the glacial period (or last upheaval of the chalk) by existing streams. In support of this fluviatile action, it has been urged that, if the land were depressed to its former level, we should then have fresh water running down these valleys, deepening their bottoms. This would not be the case. Whether the sea was elevated, or the land depressed, almost any amount of rainfall would be able to permeate the porous ground (especially at a time when there was no covering of drift, and all must admit these valleys to be preglacial), and pass readily through the open chalk rock to the water line, and thus drain into the sea in the form of a broad sheet, all along the shore between high and low water mark. No well defined surface or subterranean streams of fresh water would ever be able to exist in the chalk area.

Could we substitute chalk for the drift deposits which cover the chalk in the Holderness basin, we should then have no surface streams running there as now; all the water which now escapes in places along the inner edge of the chalk range, over the thin edge of the capping of the drift clay, would drain quietly beneath the surface of the chalk into the sea without forming any surface or subterranean streams; just as large quantities of water can now be seen draining into the sea between the tide lines. During October, 1881, Mr. Lamplugh and myself, observed at the base of the vertical cliff opposite Buckton Hall, a spring of fresh water trickling

along lines of bedding in continuous sheets, and in some places in little streams along open joints. This is a feature observable all along the chalk cliff wherever its base is swept clean of débris. These streamlets have escaped from the rock, between the existing tide-lines, ever since the sea and land held their present positions, yet there is no well marked symptom that any subterranean channel is being excavated by this natural underground drainage.

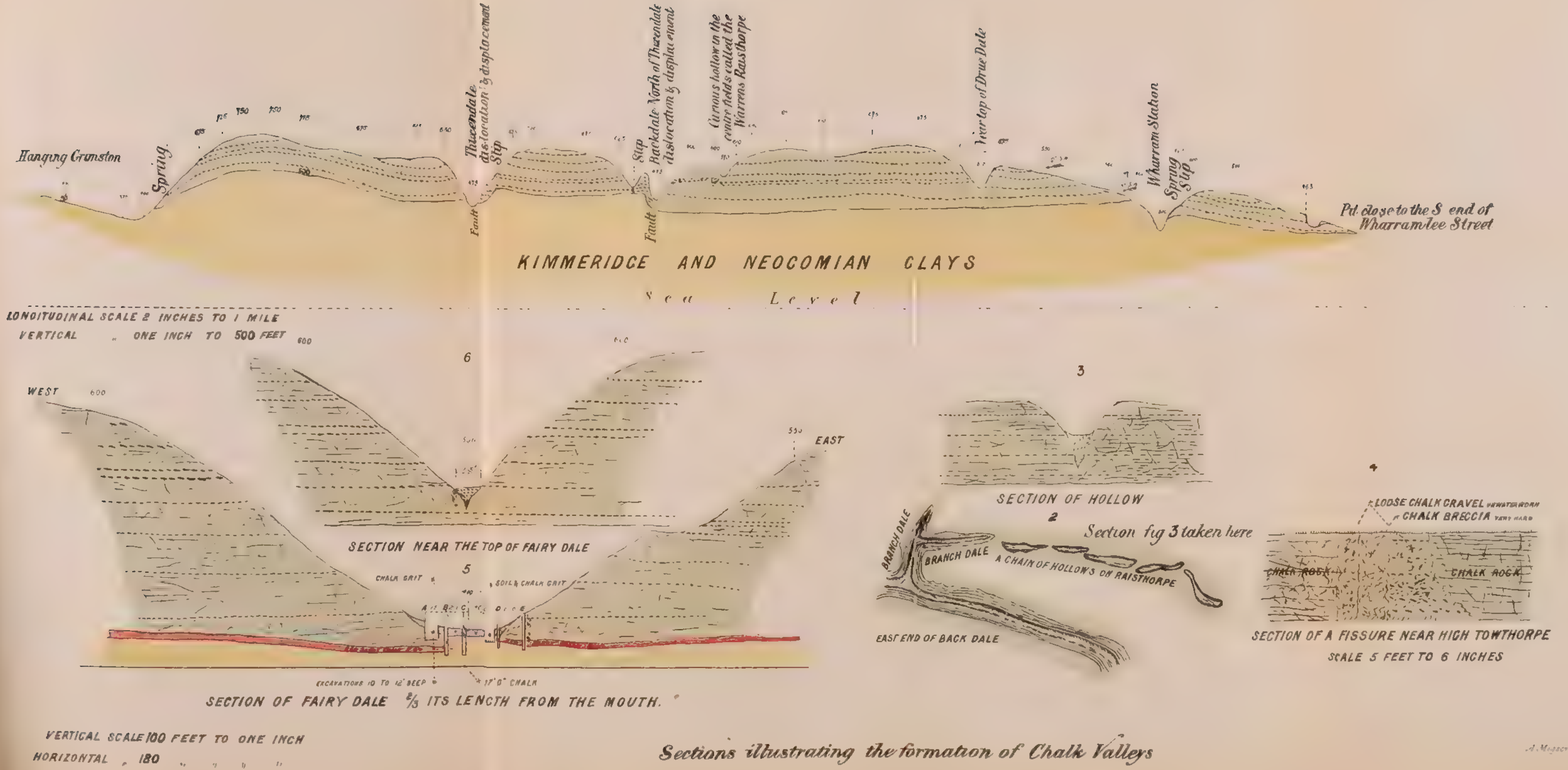
Along the out-cropping edge of the chalk, springs of water would then as now escape from the edge of hollows on the surface of the clays immediately under the chalk, or where the foot of the out-cropping chalk was the least covered with obstructing débris. These springs have been running ever since the chalk hills were pushed into their present position, without having denuded the chalk more than a few feet, or formed any visible subterranean channel, except in rare cases; moreover, the springs which are now found in valley bottoms, do not, in any case, to my knowledge, escape from the head of the valley, but from the upthrown side of the valley, and sometimes near where the side juts a little into the valley bottom, as at Thixendale and Burdale, where there is no trace of eating back in the form of an incipient side-dale. Besides these streams only run in the valley bottoms where the Kimmeridge or Neocomian clay happens to reach the surface, and as soon as that falls below the surface, the streams disappear and sink to the water-line in the chalk. The same holds good for the gypsey valley, the stream is only observed on the surface when clay is immediately underneath, except after much rain, when the subterranean water-line frequently rises and floods the surface, and then runs along a hollow or drains on the surface until it meets with higher ground, where it disappears for some distance, and becomes part of the subterranean water-sheet, after which it again appears on the surface. There is no visible appearance that such higher chalk ground is being excavated. This is just what would occur in former times; and I repeat that in such a small area as the Wolds, streams could not exist of sufficient power to excavate the existing valleys. Besides, to do this, such imaginary streams would have had to run in opposite, and in every direction.

As early as 1873, I expressed my opinion in a paper which I read to the Members of the "Driffield Literary and Scientific Society," that nearly all the valleys on the chalk wolds of Yorkshire, were due in the first instance and in a great measure, to cracks or fissures caused by the elevation of the bed of chalk into dry land, and that since the commencement of that elevation, those gaping cracks have been widened and acted upon by submarine subaerial, and all the denuding and abrading forces of nature; some of which are slowly at work now. The following is an extract from the paper I read in 1873.

"There is little doubt that the chalk was originally deposited "at the bottom of the cretaceous sea, horizontally or nearly so, and "probably in somewhat extensive areas, and that about the close of "the chalk formation, or sometime after, an upward motion, probably "due to a lateral thrust, took place, and consequently, as there is "but little elasticity in a piece of chalk, the whole mass began to "suffer rents and fissures in every direction. As the upheaval "proceeded these fissures would widen and lengthen until the "upward motion ceased. Since then, subaerial and submarine forces "have assisted to produce the present smooth appearance of these "valleys."

As early as 1873, observations in the field had forced upon me these views, and since then they have been strengthened by repeated examination and study. I wish it to be clearly understood that my views and remarks in this paper are confined entirely to the chalk area of Yorkshire. I fully admit that many valleys formed entirely by erosion do exist on many parts of the earth's surface, and to a greater or less degree exist almost everywhere. But, because we find in one place a series of valleys which have clearly been cut out by river action, we must not overlook the fact that a somewhat similar series of valleys may have been excavated in other places by other forces.

The accompanying section, No. 1, gives very strong evidence of the chalk-dales being the result of extensive dislocations, arising probably, as before mentioned, from lateral pressure. This section extends in nearly a straight line from Hanging Grimston, a point at



Sections illustrating the formation of Chalk Valleys

A. Megson & Sons Leeds

the western edge of the Wolds, north-eastwards to Wharram-le-street, and cuts at an angle of about 40° the axis of elevation running E. and W.

In further support of my theory of the formation of the chalk valleys, I will endeavour to point out and explain a few of the leading features observed along this line of section.

Commencing at the western extremity, it will be observed that the base of the chalk is about 500 feet above the ordnance datum line, and the beds dip for a short distance about 5° degrees to the S.W. This dip becomes somewhat less and less for about one mile N.E., when the beds begin to dip slightly in the opposite direction.

At this highest point the base of the chalk is 600 feet above O.D. line, and is in immediate contact with the Kimmeridge clay. Thence to that extensive rent called Thixendale (which is about 25 yards wide at the bottom where crossed by the line of section), the beds curve slightly, forming a trough or synclinal. The head or upper end of this great dale (Thixendale) begins close to Aldro on the very summit of the N.W. edge of the Wolds, and about half-a-mile from the outer margin of the chalk. Here at first it deepens rapidly, but widens gradually; afterwards it gradually deepens for some miles, and widens the whole of its length eastwards to near Driffield, a distance of about 15 miles, its course being somewhat sinuous. The bottom of its eastern end is covered for a distance of 10 miles to a depth of from 10 to 30 feet with chalk gravel, the upper 10 feet of which is well water-worn, and nearly free from earthy matter (ground chalk), mixed with subangular flints, and a few foreign boulders of various sizes and many kinds of rock; below, the water-worn appearance diminishes gradually downwards, in all the sections I have seen, and finally becomes unwater-worn, and mixed towards the bottom with angular lumps of chalk and flint to a depth of 30 feet; a greater depth I have not seen. But I know of no section where a smooth, flat surface is shown at the bottom of this dale, or any other, which should be the case if these valleys were cut down by the erosive action of rivers. The other or north-western end of this dale (Thixendale) consists, at the bottom for a distance of 4 miles, of Kimmeridge clay, except for a

short distance at its termination, where it rises upwards through the chalk. Throughout the greater length of this valley the beds of chalk on each side are found in nearly every pit to dip more or less from the centre of the valley, or in opposite directions, while the base of the chalk is *highest on the north side.* For a considerable distance along the north side of this dale, extending from Raisthorpe to within half-a-mile of Aldro, large masses of the chalk hillside have slipped to lower levels, and formed a kind of broken terrace or ledge. On the opposite or south side no well-marked slip is noticeable.

Proceeding along the line of section into Back Dale, the beds of the intervening ridge are found at first to dip 5° north and diminish to 2° north near the centre of the ridge. At the foot of the southern hillside of Back Dale, the bottom of which is in the main only a few feet in width, there is about half-way up the valley a line of remarkably formed mounds extending for about half-a-mile. The section cuts them.

During the second week in October, 1879, in the presence of Mr. Dakyns, of the Geological Survey, and Dr. Wood, of Driffield, I caused three excavations to be cut across the ridge of the most western mound, and at a depth of one to two feet, the hard chalk rock was reached, the beds of which were found standing at an angle of 35° N. in the most westerly cut, and at an angle of 65° N. in the cut near the summit of the mound. These excavations showed that the masses of the chalk had slipped from the adjoining hillside and fallen on their edges. No trace of any similar slipped masses is observable on the opposite hillside. These slips are the most striking of their kind that I know of in the Wolds; though slips of a like kind are found all along the outer margin of the chalk wolds. The above mentioned are exceeded in distinctness of form only by a line of hillock-formed masses extending from near Thorp-Bassett towards Wintringham, and called "Stack Hills." Our line of section continuing over the broad and somewhat unevenly topped high ground on the N.N.E. side of Back Dale presently cuts a chain of very curious hollows in the surface, five in number, rudely linked together at their ends, which seem to branch from a little dale, which runs

diagonally from Back Dale, as shown in diagram No. 2. They extend in an east and west direction over a mile, and run nearly parallel with Back Dale and the line of remarkable mounds at the bottom of Back Dale.

The chalk strata, as shown in a pit a little distance from the north side of these hollows, and in one close to the keeper's cottage, near the line of section, have no well-marked dip in any direction From this point, for a considerable distance, very little can be ascertained of the dip of the beds. The first pit we come to is on the south side of a hollow forming the top of Deep Dale; it is of small dimensions and exposes nothing but an accumulation of small unwater-worn chalk detritus. The dip and position of the beds of chalk are not ascertainable until reaching the southern corner of Wharram Percy Hogwalk, about half-a-mile from the eastern end of my section of this high ground; here the dip is 2° to the south. The next and most northern exposure of the rock along my section is at a spring issuing from the escarpment of a deep ravine (the entrance to Wood Dale), a little to the south of Wharram station. At this place the beds are in part composed of red chalk, and dip 5° south. Crossing Wood Dale, which is clearly in the line of a fault, the base of the chalk on the N.E. side, close to the Wharram station, is shown about 40 feet lower than it is at the spring on the opposite side of the ravine. Half-a-mile further on there is a quarry, nearly opposite Wharram school-room, where remarkable contortions are visible in the chalk, the beds standing nearly vertical.

This being the northern limit of my survey I will rapidly retrace the line of section, and give my explanation of the origin of the observed phenomena along this line.

The first feature of moment, and probably the most puzzling, is the chain of trough-like hollows (fig. 2) running parallel with, and a little to the south side of, the ridge of high ground, which forms the northern limit of my section. The form of these hollows is such as to preclude the possibility of their having been formed by fluviatile action. Neither can they possibly be attributed to the scooping action of a glacier. They possess no apparent inlet or outlet; the shallow end of one hollow passes for a little way the

shallow end of another hollow, just as cracks are frequently found to do at the foot of a landslip. They are all undoubtedly due to subterranean disturbances of the earth's crust. They are in fine, a series of small independent cracks in the rock, or incipient dales, and had the strain which produced them been a little greater, probably these rifts would have developed into one long united fracture or valley, resembling and running parallel with Back Dale and Thixendale. A section of one of these hollows (fig. 3) obtained by making an excavation across the bottom, shows it to be a V shaped cavity of unknown depth, filled (excepting some four feet of sub-soil at the top) with small unwater-worn chalk gravel, mixed with various sized pieces of angularly formed chalk, probably fallen from the sides of the hill. A careful removal of the débris from its southern side to a depth of 13 feet, exposed a jagged and uneven rock surface. In other places, not on the line of section, similar openings in the rock, and narrow ends of dales, are frequently found filled, or partly filled, with similar small unwater-worn gravel.

About one-and-a-half miles to the north-east of these hollows, a pit in the chalk near High Towthorpe exposes a fault (fig. 4) completely charged with this small unwaterworn chalk gravel, one third of which is firmly cemented together, in the form of a concrete wall which can be traced coming to the surface for a hundred yards, on opposite sides of the pit, and running in a nearly straight line E by W. This filled-up fracture in the rock, widens downwards by the slanting outwards of its S side as shown in the section (fig. 4). The oblique position of this side of the fracture could be caused only by dislocation and a downthrow.

Returning to my line of section, the next striking feature of interest is the Back Dale mounds. I have already shown that they are slips from the adjoining hill side, but it remains to be told how they obtained their present position. It will be observed that the line of section exposes the Kimmeridge clay at the bottom of this dale; after a few feet of detritus, clay has been reached in making post holes.

I believe that the base of the chalk on the south side of this dale is several feet higher than on the north side. This would

admit of the clay being squeezed out and washed away at the S. side of the dale; and here and there masses of chalk left unsupported would break off and fall on their edges, in the position now occupied by these Back Dale mounds.

Again, on reaching the next dale (Thixendale) we observe, as previously mentioned, displaced masses of rock on one side of the valley only. The base of the chalk on the north side of the valley is from 20 to 50ft. higher than on the south side; the weight of the superincumbent rock, resting on yielding clay, has caused masses of chalk along the north side of the dale, to break off and slide to lower levels, leaving a ledge or terrace above, and somewhat increasing the dip of the beds of these slipped masses. Springs, one at Burdale, and one at Thixendale, issue from this side of the dale only.

From the opposite dip of the beds on the two sides of the valley, as shown in the section, you will observe that this dale (Thixendale) runs for some distance along an anticlinal, the very place where the greatest strain would be, and a fracture most liable to occur, and the force has been sufficiently great to completely sever the rock here and in Back Dale, and to throw up the intervening mass to a height varying from 10 to 50 ft.

Other important displacements exist in this neighbourhood. Near Burdale, about 2½ miles E. of my line of section, at the junction of Fairy Dale with Thixendale, there is a well ascertained fault; at the west side of Fairy Dale a fine spring of water issues, and the red chalk comes to the surface, while on the same level at the opposite side, close to Burdale Station, about 60 yards distant, a well was sunk about the year 1867 more than 50ft. in depth, through somewhat disturbed rock, and it was at the bottom only, that red chalk was found. In the autumn of 1880, I obtained with the pick and the boring rod, a section (fig. 5,) across the bottom of Fairy Dale, at a point about ⅔ of a mile from the mouth of the Dale, and a little N.E. of "Fairy Stones," which also proved faulting. But here the downthrow is only about 8ft., and what at first seemed a little perplexing, is on the W. or opposite side to the downthrow at the mouth of the dale. Fortunately the cause of this anomaly is near at hand.

The Fairy Stones, near to it, previously mentioned, are large

masses of chalk and flint breccia protruding from the west side of the dale; near the brow of the hill, an extension of them can be traced coming, in places, to the surface and running almost at a right angle from Fairy Dale, some distance over the fields in the direction of the head of a valley called Wood Dale, coming from the Northern edge of the chalk area, past Wharram Station. These Fairy Stones, and the line of breccia observed on the surface undoubtedly fill a fissure in the rock, connecting Fairy Dale with the head of the valley (Wood Dale) coming from the northern escarpment. Mr. C. Fox Strangways informs me that at the northern entrance of the Burdale tunnel, the Kimmeridge clay is above the 500 contour on the W. side, and at about the 450 contour on the E. side, thus showing the base of the chalk to be 50ft. higher on the former than on the latter side of the valley (Wood Dale.) This proves almost for certain, that a fault extends into Fairy Dale, and causes the downthrow on the N. side of Fairy Dale in my section; while there is a downthrow on the south side at the mouth of the valley. I also made a section further east, near the termination of Fairy Dale, where the bottom is very narrow; and at a depth of 10ft., the two sides of the valley joined, forming a V shaped rent (fig. 6,) containing, for the most part, unwaterworn chalk gravel mixed with lumps of chalk and flint. Its sides were sharply rugged, jagged and uneven, showing no trace of water action, but every appearance of a gaping crack.*

Faultings in the chalk are not confined to the neighbourhood of my section. Mr. C. Fox Strangways has kindly favoured me with a section of Wold Dale taken at Park Farm, near Londesborough, and writes:—"On the west side the lias clays run up to nearly the 225 contour, whereas on the east side which is only 90 yards off, there is no lias at all, the chalk going to the bottom of the valley about the 175 contour or less." In answer to my suggestion that this must be due to a fault, he replies:—"I think the irregularity observed at Park Farm is very likely due to a fault; at the same time it may also arise from the chalk having

* I also excavated the narrow end of "Big Dale" near Fimber, and found a similar appearance.

been deposited upon a hill of lias clay. The red chalk is seen at the corner of the valley just south, so the fault would not be a large one. The fault also would have to wind about a good deal, and I do not like winding faults." In reply to this it seems improbable that a yielding substance as lias clay should present such an irregular surface at the time of the deposition of the chalk, as to account for the different elevations of the base of the chalk in the valley bottoms. And if we admit this for the lias clays, we must also admit it for the Kimmeridge and the Neocomian clays, which are more frequently found to differ very considerably in elevation, in very short, distances, between one side and the other side of a valley. The irregularity of the base of the chalk, in Wold Dale, as sometimes in others, and the apparently crooked appearance of the dale, or fault, may be partly due to the masses of chalk having slipped from the upthrow or western side of the valley, to lower levels, and so masked the true base of the chalk, which on the upthrow side is often higher than it seems, besides, a small fault might as easily be crooked as straight.

In further support of my theory of the great strain and displacement the cretaceous beds of Yorkshire have sustained, I wish to mention the fact, though the general dip of the whole mass is to the E. and S.E., scarcely any two adjoining pits show the same degree, or direction of dip. Local variations in the disturbed beds are numerous and frequently great. Crumpling of the strata is also frequent. In the Bempton cliffs, a little north of Flamborough, there is a grand example of the crumpling of beds, extending from top to bottom of the cliff, a distance of about 300 ft., with a slight variation at the bottom. At Foxholes, Weaverthorpe, Langtoft, Whinmoor Build, Heslerton Brow, and in two places in the railway cutting between Marton and Hunmanby Stations, are similar extensive crumplings and displacements of the chalk strata, in some places attended with slight faulting. Many minor crumplings may also be observed throughout the area. Though these crumplings are most likely due to a period of subsidence, acting on lines in a certain direction; while the valleys were formed during a period of upheaval acting along lines in a different direction; they clearly indicate extensive terrestrial

movements. Thus we find the chalk beds contorted, squeezed, crumpled, shattered, fractured, and faulted in almost every direction, giving clear indications of the effects of subterranean forces. We also seem to have evidence of considerable disturbances even during the formation of the chalk. In Silex Bay, near Flamborough, there are contortions in the strata, which though greatly masked by drift slipped from above, seem to be over-laid with nearly horizontal and almost undisturbed beds of chalk. Then again the black carbonaceous band 6 to 20 inches thick, observed about 50ft. from the base of the chalk near Londesborough at Drewton in pits on each side of the Wharram Station, and in the railway cutting on the west side of the line a little south of Hunmanby Station; also discovered about 3ft. in thickness, in sinking a well at Fordham in 1857; and seen recently at the base of the cliff opposite Buckton Hall, a little north of Flamborough, is probably due to disturbances during the deposition of the chalk. At the latter place it is not thick, and there is a slight trace of unconformity, or false bedding in the adjoining beds; a thin bed of broken and crushed chalk, somewhat brecciated, lies immediately under the black band; and the two clearly divide, at this place, the grey chalk from the white chalk with flints. A somewhat similar bed of crushed chalk 4 to 6 in. in thickness, is observable in a pit, about $\frac{3}{4}$ of a mile east of Market Weighton. These horizontal beds of crushed chalk, indicate local shearing of the beds, under great pressure; whilst there can be little doubt that the dark band is due to an abnornal deposition, after some violent disturbance of the sea; probably some subterranean movements caused the waves to break up and for a time hold in suspension, a large quantity of the adjoining and outcropping Lias, Kimmeridge, and Neocomian clays. On the subsidence of such a turbulent condition of the cretaceous waters, dark matter combined with calcareous and argillaceous particles, also held in suspension by the troubled waters, would settle down into just such a band; differing slightly in thickness and colour here and there as we now find it.

In addition to the places previously named, Mr. C. Fox Strangways kindly informs me that this black clayey chalk was found in well-sections at Helperthorpe, Weaverthorpe, and Butterwick;

and that the band is well seen in most of the quarries along the Wold edge in Lincolnshire. Its stratigraphical position is near the somewhat indefinite line, which separates the grey chalk from the white chalk; and I am not aware that it has been found at any other horizon. To disturbances only can we moreover attribute the almost innumerable beds of fullers earth, which exist throughout the whole thickness of the chalk. Some of these beds, 1 to 3 in. in thickness, are, like the black band, probably due to subterranean movements affecting the bed of the ocean and troubling the waters, the smaller ones, some of which are hardly sufficient to separate the laminæ of chalk which they divide, are, as mentioned in a previous paper of mine, undoubtedly due to ordinary ocean storms, acting on, and breaking up more or less the forming chalk below; during the succeeding calms seams of fullers earth were deposited, which thus produced the innumerable laminæ observed throughout the chalk formation, To no other cause can these fine divisions be attributed. If a section be drawn from Acklam on the western edge of the chalk, to Hornsea on the eastern coast-line, we shall find the base of the chalk to be 1,400 ft. higher at the former place than it is at the latter. Though part of this great difference may be due to chalk having been deposited in a basin-shaped hollow, upheaval has been an important factor in placing the beds along its elevated outcrop it their present position. An interesting feature is attached to the most elevated portion of this outcrop. The valleys on its outer edge, are sharply defined, whilst the hill tops show comparatively little trace of denudation. But along the inner margin of the out-crop, the valleys are greatly widened, and the hill tops are much planed down, the material being carried down to lower ground (lowering hill and filling up dale) and producing a level appearance; strikingly in contrast with what is observed on the outer and elevated side of the out-crop This great difference of appearance cannot be due to subaerial denudations, or we should have the outer side of the out-crop, which most probably, was the first to emerge from the cretaceous sea, quite as much if not more denuded than the inner. What then have been the causes that have acted so unequally upon the inner and the outer sides of the out-cropping

chalk area? This is no easy question to answer. But it is fair to presume, that in the first instance, the outer or that part of the chalk area whose base is now the highest, was the first to rise, and probably somewhat suddenly, above the action of the cretaceous waves. The inner edge was just sufficiently elevated to catch the full denuding force of the tides and storms of the cretaceous sea. Afterwards, probably, the chalk rose more slowly and consequently the inner margin would remain under the full and long continued action of the ocean waves. Such a probable state of things would, in a great measure, account for the very different degrees of denudation, which the two sides of the chalk wolds appear to have sustained. Since the formation of the chalk, denudation, submarine, and subaerial, has ever tended to plane down prominences, widen and heighten the bottoms of the main valleys, and fill up some of the smaller ones. I have also shown, in a paper published in the proceedings of the Yorksh. Geol. and Polyt. Society (Vol. VII., part IV., page 373 to 380.) the great probability that the inner edge of the chalk outcrops, suffered considerably more from denudation, during the glacial period than the outer edge. Lastly, in returning to complete my line of section, we observe that the slipped masses at its west end, are such as occur all along the outer margin of the wolds, and are due to the action of water constantly removing the clay under the edge of the chalk. This removal of clay may have let down the beds and produced the general outward dip which we observe, close along the whole of the outer edge of the chalk range.

In conclusion, I must repeat with emphasis, that, it is difficult to receive the erosion theory as sufficient to account for the formation of the grand system of the Yorkshire chalk valleys. But, if we admit that the numerous fractures, contortions and displacements above mentioned, which are everywhere visible must have been the natural result of such a non-expansive substance as chalk having to accommodate itself during periods of upheaval to a larger surface area, the origin of this system of valleys becomes clear. They are due originally to fractures in the crust. Their present rounded outlines have been moulded by subsequent denudation.

ON THE CONTORTIONS IN THE CHALK AT FLAMBOROUGH HEAD.

BY JAMES W. DAVIS, F.G.S., ETC.

The Photographs issued with the volume of proceedings for the current year illustrate a series of gigantic contortions in the Chalk at Flamborough Head in Yorkshire. Between the eastern extremity of the Head, where the Lighthouse is placed and the Speeton Cliffs, is a distance of about 6 miles, and the part of the cliff from which the Photograph is taken is nearly midway between the two, at a place designated Staple Nook, a small bay in the Bempton Cliffs. The northern shore of the bay is formed by a promontory of the chalk which has been pierced and forms an archway: this is called on the ordnance map Scale Nab. The opposite extremity of the bay is formed by a series of arched rocks which is styled 'Old Door,' the popular name amongst the fishermen is always 'Staple nook.' The Cliffs at this part of the coast are quite inacessable, and the sea washes up to their base at every tide. North and south of the contorted strata at Staple Nook, the sea never leaves the perpendicular face of the Cliff which descends sheer into the water to a considerable depth below the tide at low water mark. The only means by which access can be got to this part of the beach is by boat from the North Landing at Flamborough, and only thence in fair weather. The great cliffs, beautiful in their stupendous grandeur, and the sunken and treacherous rocks extending seawards at their feet, demand the exercise of caution in venturing amongst their concealed dangers except when the sea is calm and the sky clear. Under favourable circumstances a visit to the contorted chalk will be found not only instructive, but extremely enjoyable. At North Landing the chalk cliffs have dipped down to a very moderate thickness, but this is compensated by the great thickness of the superincumbent Boulder Clays, worn by the action of the rain and frost into ridges and peaks of peculiar and fantastic forms. Further west where the chalk increases in thickness, the glacial clays become proportionately thin. The contours at Thornwick are very fine, as

seen from the sea; the chalk forms alternate promontories and bays, the former are carved by the never-ceasing action of the tides, into innumerable caverns and fissures. As the boat proceeds along the shore the cliffs gradually become higher until the maximum of 446 feet is reached. Myriads of guillemots and puffins occupy the ledges and crevices of the rocks, on which they lay their eggs and rear their young. Their swooping, circling flight, and shrill cry renders both the air and sea a source of interest to the naturalist.

Extending seawards from the base of the cliff great boulders cover the beach and afford evidence of the power of the waves, in combination with frost, to break up even the mightiest cliffs and the hardest rocks. The boulders make it difficult to land from a boat, and the fucoid growth covering their surfaces do not add to the pleasure of scrambling over them to attain the narrow strip of sandy beach which extends along the immediate front of this cliff. It is interesting to observe the emergence of a subterranean stream at the right extremity of the section, a good example of the underground drainage of the chalk wolds.

The chalk in the S.E. portion of Yorkshire, extends in a great semi-circle from Flamborough, first westwards and then southwards as far as the Humber at Ferriby and Hessle. It forms an elevated and undulating series of hills separated by deep ramifying valleys, along the bottom of which streams run only at intervals after heavy rains, and when the chalk is charged with a larger quantity of water than can be conveyed to the sea by the ordinary underground channels.

The chalk of the Yorkshire Wolds is usually of a hard and more or less flaggy nature, the layers separated by a fine unctuous clay resembling fullers earth, in this respect it differs from the chalk of the south which is thick-bedded and much softer. The lower beds of the chalk, as may be seen in the cliffs of Buckden and Bempton, abound in layers of nodular flint, whilst those higher in the series forming the cliffs further south are almost devoid of flints. Mr. Fox Strangways has pointed out that the occurrence or otherwise of flint has a marked effect in the character of the soil above the chalk; the northern district of the wolds westwards from Hunmanby

being very flinty and with scarcely any good soil, while the districts south of the great wold valley by Twing, Rudstone. and Boynton has but little flint, and forms a deeper and heavier soil.

The chalk hills or wolds terminate eastwards in Flamborough Head. Northwards, the chalk overlies the Neocomian clays of Speeton, and southwards dips under the glacial hills and alluvial deposits of Holderness. The action of the waves on these softer beds has resulted in the formation of bays of considerable extent, whilst the hard, massive chalk has resisted the encroachment of the sea and forms a bold headland with grand escarpments, which, at Bempton and Buckden, attain a height of more than 440 feet. It is in these cliffs that the contortions occur. The disturbed portion of the strata extends for a distance of about 300 yards, and from the summit to the base of the cliff the chalk is bent, folded, and crushed in every conceivable manner. The appearance is rendered more remarkable by the contrast this part of the cliff presents to that extending north-westwards or south-eastwards, in which the strata exhibits only a slight and uniform inclination southwards.

The Photograph, No. 1, exhibits the whole of the contorted section exposed in the cliff. To the left of the section the chalk extends in nearly horizontal layers; it first makes a sharp curvature downwards to the north at an angle varying from 45° to 60°, as shown in the photograph. The beds vary in thickness from a few inches to 6 or 8 feet at this point; but further to the right or N.W., where the disturbance has been greatest, the beds become thinner.

From the level of the sands, which may be discerned forming a narrow strip between the base of the cliff, and the masses of large boulders in the foreground, to the summit, a height at this point of 275 feet, the layers of chalk may be seen dipping at the angle indicated above with great regularity. Suddenly the layers resume a horizontal position, and a huge mass at the base of the cliff, though in its natural position, has the appearance of having slipped from the inclined strata above into a horizontal position on the sands. The horizontal arrangement extends to about half the height of the cliff: the upper portion gradually assuming an upward inclination at an angle at first obtuse then a right angle. The strata next

forms an immense variety of contortions, of which the photograph No. 2 affords a good example. It is taken at a point about two-thirds the length of the section depicted in the photograph No. 1, from its left margin at the base of the cliff. The layers are folded and bent repeatedly at very sharp angles, they are thinner than those to the left, already named. Occasionally the layers of chalk are broken and displaced, as in the summit of the arch forming the roof of the cave shown in the photograph; in other instances, the layers appear to exhibit a large degree of mobility, and they have been squeezed in many parts so as to form a very sharp angle, and remain unbroken, exhibiting a continuous and unfractured texture. The anticlinals have, in several cases, been formed into caves, due to the action of the tides on the dislocated strata. Even at a considerable distance higher than the base of the cliff, the action of the sea has bored its way into the chalk, and many orifices, some of considerable size, bear witness of the energy of the north-eastern gales.

Numerous small faults and comminuted fractures next intervene and indicate where the strain has been greatest; the faults do not in more than one or two instances extend through the whole section. Towards the right of the photograph, No. 1, the strata may be distinguished dipping at an angle between 70° and 80° to the north, next they turn upwards and dip at an equally sharp angle in the opposite direction, some of the beds are perpendicular, and at the base of the lower portion of the cliff near the extreme right of the section the strata may be seen curving over in the form of the letter **C** (see photograph No. 3), the lower part of the curvature then extends almost horizontally to the extreme right of the section, which forms a magnificent headland through the base of which the sea has carved a stupendous arch.

The extension of the contorted strata inland has not hitherto been traced. The surface of the wolds for the most part affords very little evidence of the character of the rocks beneath, and it is only where an occassional quarry has been formed to obtain material for the repair of the roads that a section of the chalk is obtained. Such a one may be seen in the hill side on the road between Weaverthorpe Station and the village. The chalk in this quarry is

inclined at a considerable angle, and it is possible may indicate the direction of a branch of the contorted strata. On the one-inch geological map of the Flamborough district, the probable line of the disturbance is marked as extending due west from the cliff, passing about one mile south of Speeton village. There are several exposures of chalk dipping at high angles which Mr. Fox Strangways considers may be caused by the same set of contortions: they may be seen in the railway cutting near Buckden Hall, near Bartingdale plantation, north of Wold Newton, north of Foxholes, and near Hall plantation.

Having briefly described the position and character of the contortions depicted in the photographs, it may be desirable to consider with equal brevity the probable cause of the displacement. The chalk in Yorkshire, speaking broadly, is arranged with tolerable regularity, the strata dipping to a point S.E. of its eastern boundary, the strata towards its southern extremity in this county dips in an easterly direction, that which forms the northern portion dips in a southerly direction. The interposition of this immense mass of contorted chalk is all the more peculiar on account of its rarity. It is very doubtful whether any other locality in the chalk area of Yorkshire exhibits so great an amount of disturbance, and the question naturally arises as to how the beds came to be folded and faulted in the manner described. They are for the most part bent and doubled into a series of anticlinals and synclinals, but along the line of greatest pressure or possibly of greatest weakness, the beds are broken and faulted. The strata were deposited in a more or less horizontal position, and the violent contortions they now exhibit have been produced since their deposition. The continuity of the beds, notwithstanding the immense pressure to which they have been subjected, proves that the action causing their displacement took place long after the deposition of the chalk, at any rate a period sufficiently long to allow the strata to become consolidated and hard must have elapsed, or otherwise the whole would have been squeezed into an amorphous mass, and the bedding would have been obliterated. The series of anticlinals may have been produced either by a pressure from below, or by a contraction of the surface causing a latural pressure. Prof. A. H. Green

(Geology for Students, 1876, p. 375,) enters into the relative merits of this question with considerable detail. If a horizontal bed of chalk be subjected to pressure applied vertically from below so as to produce a series of anticlinals and synclinals, it is evident that the bed will become longer if bent into a series of curves than it was when simply straight. If, on the other hand the pressure has been applied laterally, the bed of chalk will be compressed or squeezed into a smaller compass. Prof. Green says:—"Where rocks have been sharply bent into folds which follow one another in rapid succession, they would have to be pulled out to many times their original length to bring them into their present shape. Even supposing rocks as extensible as india-rubber, increase in length must be attended by a corresponding decrease in thickness, and therefore a group of rocks, when sharply folded, ought to appear to be more thinly bedded than in their undisturbed position. But if we take a group of rocks which lie undisturbed at one spot, and one violently contorted at another, we do not find the beds thinner at the latter than at the former. In reality, however, rocks are only slightly extensible, and it is utterly out of the question to suppose that they could possibly have been dragged out to the extent necessary to bring them into their present form by vertical upthrust. No such difficulty accompanies the squeezing hypothesis: a band of rock, which when horizontal was, say, a mile long, is forced to occupy a smaller space, say, three-quarters-of-a-mile, and the only way in which this could be done is by puckering it up into folds."

It is very probable that the foldings or contortions were produced, not only at a period long subsequent to that of their deposition, but also after the accumulation of a considerable mass of superincumbent matter, so that when the operations were in progress the contorted chalk was buried beneath a great thickness of strata. This will be evident if it be considered that a large amount of material has been removed from the upper surface of the section now photographed. The upper portion of the arches has been to a large extent removed by denudation, and there is a strong probability that at least some hundreds of feet of chalk have been carried away by this means. Experiments conducted by Prof. L. C. Miall and

described in the proceedings of this Society for the year 1872, proved that the productions of the contortions must have been a slow process. He invented an apparatus for applying a regulated pressure which could be continued for a long time: and with this, experiments were conducted on thin slabs of limestone and sandstone. It was found that whilst the pressure was maintained the slabs to a certain extent remained unbroken, but as soon as the pressure was removed the slabs cracked. This was in some measure remedied by embedding the slabs in pitch, but with this assistance only a small amount of curvature could be obtained without breakage. From these experiments it is inferred that a uniform and long-continued pressure is required to produce an unbroken curvature; and strengthed the opinion that continuous unfractured anticlinals and synclinals are only formed under a considerable weight of superjacent strata. The acute angles at which the beds of chalk are folded in the section at Staple Nook, must lead to the conclusion that the pressure producing them was more or less continuously applied in a horizontal direction, that it extended over a very long period, and that whilst in operation there was a considerable thickness of superimposed rocks above the contorted chalk, representing a sufficient weight to keep the compressed strata intact.

ON SOME SECTIONS AT CAVE AND DREWTON. BY REV. E. MAULE COLE, M.A., ETC.

During the construction of the Hull, Barnsley, and West Riding Railway, I had, by the kindness of the engineers, every facility afforded me for studying the sections. I propose in the present paper to bring before the society a few features which struck me, confirming my remarks on the Wold sections.

The new railway cuts across the various beds at right angles and in the short space of two miles passes from the lower lias to the chalk.

There are three cuttings between North Cave and Drewton. In the first a ferruginous sandstone was exposed belonging to the

A. spinatus zone of the middle lias, resting on clay containing fossils associated with *A. capricornus*. The foundations of a bridge immediately west of this cutting were laid in beds producing *Gryphœa incurva* or *arcuata*, as it is sometimes called, and therefore belonging to the zone of *A. Bucklandii* of the Lower Lias. No traces of Upper Lias were seen, but Mr. Fox Strangways informs me that the *A. communis* zone is probably there.

The next cutting is in the Cave Oolite, equivalent to the Millepore Limestone of the Lower Oolites. The blocks of stone exhibited a distinctly oolitic structure and were mostly blue-hearted, the external portions having been oxidized.

The third cutting at Drewton gave a splendid exposure of the Kelloway rock. At the base were some fine white sands to be seen in a quarry at Sancton close to the church and roadside. This was succeeded by darker sands containing many concretionary nodules or doggers, which in several instances were left sticking out in the sides of the cutting: higher up, dipping towards the east, was a band of hard sandrock containing innumerable shells of *Gryphœa bilobata*, lying as in a natural bed, with both valves united. The Kelloway, towards the east, was covered with Oxford Clay, containing *Belemnites owenii*, which was in turn covered with Boulder Clay, the whole being surmounted by chalky flint gravel and sand.

At the fourth cutting, near Weedly, the lower beds of the chalk, red and grey, were reached at a distance of nearly two miles from more the steep escarpment of the wolds, possibly due to landslips, but probably a *remanié* of the chalk which once extended far across the Vale of York. From thls point to near the entrance of the Riplingham tunnel (one-and-a-quarter miles in length) a streak of black chalk was visible lying between the grey and the flint-bearing white chalk. At one point especially, not far from the western end of the tunnel, a seam of black chalk, 3ft. thick, was exposed, darker in the centre than at the sides. On treating it with muriatic acid, it effervesced, and the residue was set fire to, showing the presence of carbons.

A fine cutting, 83ft. deep, on the eastern side of the Riplingham tunnel displayed several beds of tabular flint, which are intermediate between the grey chalk and the flintless upper chalk of Yorkshire.

On the foregoing facts I propose to make a few observations.

To any one who has studied the Liassic and Oolitic rocks of North Yorkshire, an immense difference will be at once apparent between them and the rocks disclosed by the railway, pointing to the conclusion that they could not all have been deposited under similar circumstances, or in the same area.

1.—With respect to the Lower Lias there is not much to guide us. These beds are however better exposed in the southern than in in the northern area, and it would seem that as there is no material difference, they were deposited under the same geographical conditions.

2.—It is very different with the Middle Lias. In the zone of *A. spinatus* in the northern area occurs the vast deposit of iron ore which has given rise to the Cleveland iron trade. Whatever may have been the source of this iron, though probably volcanic, it seems to have been confined principally to a district between the Tees and the Esk; certainly it thins out southwards and no trace of it is found south of the anticlinal, sketched by Professor Phillips, in the line of Garrowby Hill. In Lincolnshire the iron ore of Scunthorpe is worked in the lower, *A. Bucklandi* beds, not in the Middle Lias.

3.—Then again in the neighbourhood of Cave, though it would be hazardous to say that there are no alum shales of the Upper Lias, it is certain that there is no jet. This ancient and useful natural material for ornament, found in pre-Roman tumuli on the wolds, is confined to the *A. serpentinus* zone of the Upper Lias in the neighbourhood of Whitby. In the southern area it is wanting, and its absence marks a dissimilar condition of affairs.

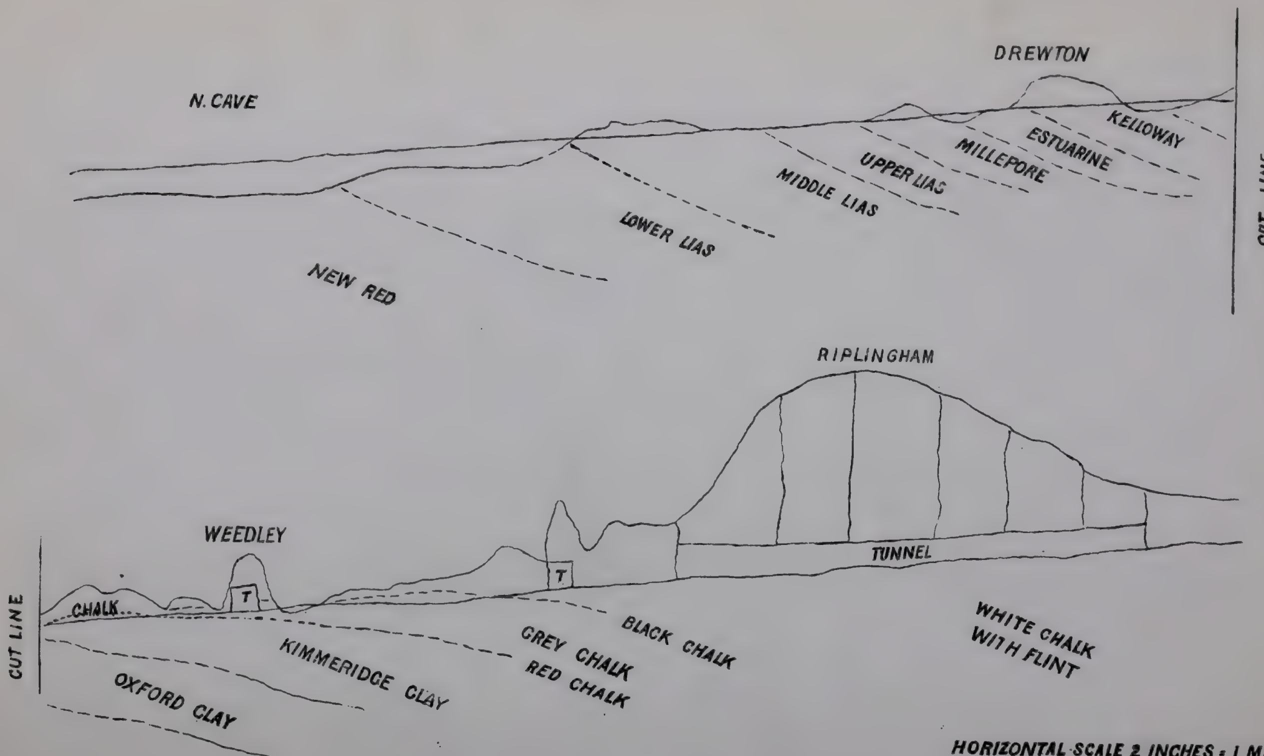
4.—From the Lias to the Kelloway occupies only a short distance on the railway, yet the only rock distinctly prominent is the Millepore Limestone. The great sandstones of the Lower Oolites, which form the Moorlands of North Yorkshire, seem to have died out altogether in this southern area; probably they never extended so far. They came from the north and were deposited near a shore line, and would be cut off altogether from the district under review by a submarine ridge in the direction of a line from Garrowby to the coast.

5.—The fine development of Kelloway rock was scarcely to be expected. The grand platform from Newton Dale to Scarborough, on which the tabular hills rest, thins out southwards from 80ft. near Saltergate to only 5ft. or so in Gristhorpe Bay. Here at Drewton it is 35ft. thick. In one place, Sancton, a few miles north the sand is pearly white; just south of the railway it is of various strongly marked colours with a peculiar smell. Instead of coming from the north, as the Kelloway in the northern area did, it may have come from the west.

6.—The Oxford Clay above it again is unlike the clay of the northern area. This latter is loose and friable and light-coloured, scarcely to be called clay. The clay at Drewton is real clay, stiff and tenacious, of a deep blue colour, and thus presents another contrast.

7.—Above the Oxford Clay the Corallian Rocks in the southern area are wanting altogether. There are no grits, no rag, in short, there were no coral reefs. The land evidently sunk after the deposition of the Kelloway sandrock to some depth, whilst the Oxford Clay was being deposited, and continued too deep for the growth of coral, which cannot exist below some twenty fathoms. Everything in fact points to the conclusion that the area south of the anticlinal somewhere about Pocklington to the basin of the Humber was disconnected with the typical area of the Lias and Oolites of the north, and only partially connected with the Lincolnshire area to the south. It has a history of its own.

8.—The Carbonaceous Black Chalk I wish particularly to call attention to. If chalk were formed in a *deep* sea, as some suppose, I do not see how this band of vegetable matter could have accumulated. In my handbook "Geological Rambles in Yorkshire," I expressed an opinion that chalk was formed in comparatively shallow basins, and gave certain reasons. The discovery of this black band adds another to those already advanced.



HORIZONTAL SCALE 2 INCHES = 1 MILE
VERTICAL " 200 FEET = 1 INCH

SECTIONS AT CAVE AND DREWTON

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NOTE ON SPIRANGIUM CARBONARIUM (SCHIMPER). BY REV. J. STANLEY TUTE, B.A.

I wish to record the occurrence of a specimen of *Spirangium carbonarium* in carboniferous sandstone. It was discovered in breaking a boulder of sandstone from the drift. Unfortunately the man (who was breaking stones for the repair of the road) only preserved the fossil, and not the matrix, so that we have only an internal cast, together with the substance of the fossil itself to determine its nature and geological position.

SPIRANGIUM CARBONARIUM. Schimper.

All the sandstones in that part of the drift in which it was found, are in no case more recent than the Plumpton Grit; this, which is certainly not Plumpton Grit, must be from older rocks, probably from one of the members of the Yoredale series. This is interesting, as the oldest specimen of Spirangium hitherto described is from the coal measures of Coalbrooke Dale, and is described in Professor Prestwich's paper, Plate XXXVIII., Fig. 12. The following species, as well as this, are described in Schimper's Paléontologie Vegétale, Vol. II., p. 514, Pl. 80:—

1. Spirangium carbonarium. Upper Coal Measures, Wettin, Saxony.
2. S. regulare. Bunter, Soultz-le-bains, Alsace.
3. S. Quenstedti. Variegated chalk, Keuper sandstone, Waldhausen.
4. S. Münsteri. Rhetic, Strullendorf, near Bausberg.
5. S. ventricosum. Inferior Lias Sandstone, Couches Autun.
6. S. jùgleri. Clay Schists Wealden, Deister, Hanover.

THREE NEW SPECIES OBSERVED IN THE YORKSHIRE LIAS. BY W. Y. VEITCH, ESQ.

Whilst studying the Yorkshire Lias, collecting and identifying its fauna, several forms have been put aside for further and more careful consideration. Three of them have turned out to be species not previously described :

Chonetes Clevelandicus, Figs. 1 and 2, is a brachiopod found attached to Waldheimia resupinata, and occurs in the main seam of ironstone in Ammonites spinatus zone at Eston. 3 examples.

Pleuromya navicula, Fig. 3, is found in the Ammonites oxynotus zone, Robin Hood's Bay. Although several specimens have been secured in a fragmentary condition from the shale Fig. 3 is the only perfect one I have been able to obtain, its preservation is due to its pyritous condition.

Isis liasica, Figs. 4 and 5. These figures are from fragments of a sclerobasic coral, and are of interest, because I can find no record of any such coral having been found in the Lias, it is of the tribe Isinæ. I have noticed it in the Ammonites capricornis and A. Jamisoni zones at Huntcliff and Rockcliff, and A. oxynotus zone, Robin Hood's Bay. Fig. 4 was picked out of the shale of the last named zone, whilst Fig. 5 is from a sandstone nodule in the first zone. It is common and gives the appearance of a robust horny based coral branching dichotomously, and is inclined to be arborescent, and must have been three or four feet in height. Sections of it under the one inch objective show a coarse cellular structure at the outer margin, this disappearing towards the centre where parallel striæ become apparent, resembling the striæ in horn.

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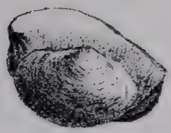

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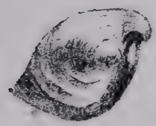

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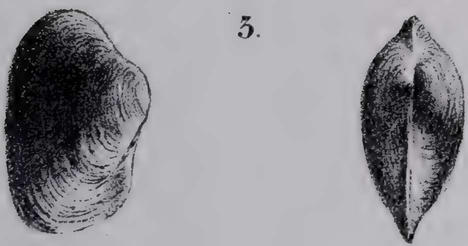

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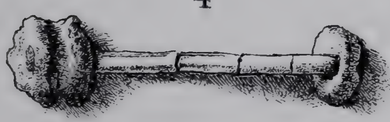

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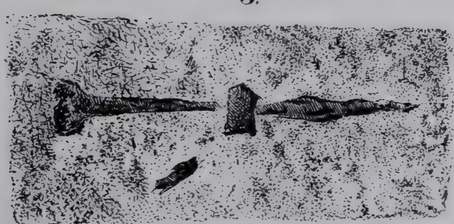


NEW LIAS FOSSILS.

A. Megson & Sons. Leeds.

ANALYSIS OF A HYDRAULIC LIMESTONE CONCRETION FROM THE YORKSHIRE COAST, WITH REMARKS ON CONCRETIONS GENERALLY. BY H. B. STOCKS, ESQ.

In the lias of the Yorkshire Coast nodules of Hydraulic Limestone occur, these nodules when "burnt," form a good hydraulic cement. The nodules are generally rounded, but flattened, grey and very hard, and contain the remains of ammonites, etc.

Analysis of the Hydraulic Limestone of several localities have been made, but that from Yorkshire does not seem to have been examined. In continuation of my investigation into the chemical composition of various concretions, I have examined one of these from Sewerby, near Flamborough. A qualitative examination showed the presence of oxide of iron, alumina, lime, iron pyrites, sulphuric acid, carbonic acid, silicic acid and phosphoric acid. The estimations of the amounts of these constituents gave the following figures :—

		Sewerby.	Isle of Sheppey.
Ferric Oxide	Soluble in Hydrochloric Acid.	5·49	——
Ferrous Oxide		——	4·32
Alumina		0·90	0·39
Lime		38·61	37·51
Magnesia		——	0·79
Silica		0·68	——
Carbonic Acid		31·79	32·99
Sulphuric Acid		Trace.	——
Phosphoric Acid		0·24	——
Ferric Oxide	Insol. in Hydrochloric Acid.	2·90	1·72
Alumina		11·63	4·32
Lime		——	0·05
Magnesia		——	0·37
Silica		2·54	16·89
Iron Pyrites		1·87	——
Water		0·78	——
Alkalies and loss		2·57	0·65
		100·00	100·00

For comparison with my analysis, I quote one from the last edition of Muspratt's Chemistry.

It will be seen from the above analysis, that the nodules consist essentially of a mixture of carbonate of lime and clay. The phosphoric acid most probably comes from the shells which the nodules contain. The presence of phosphoric acid in these nodules does not seem to have been noticed previously, I have discovered it in all the nodules that I have yet examined, and it has been found in the nodules of clay ironstone used for iron smelting, in the proportion of from a trace to 1·86 per cent.

It appears that many substances are capable of forming concretionary nodules, but only a few occur in large quantities; these are carbonate of lime, carbonate of iron, iron pyrites, silica, and phosphate of lime. Iron pyrites occurs nodular in the chalk and in the clay of the coal measures. Silica occurs nodular in the chalk, as flint, jasper, etc. Phosphate of lime occurs in nodules in the greensand and other formations.

The other concretions found in considerable quantities are:—

Coal Balls consisting of variable proportions of carbonate of lime and iron pyrites.

Baum Pots consisting of a mixture of carbonate of lime, iron pyrites, and silicate of alumina (clay).

Acrospire, a curious concretion found in the millstone grit, consisting of carbonate of lime and sand (silica).

Clay ironstone consisting of varying amounts of carbonate of iron and silicate of alumina.

Chert consisting of a mixture of carbonate of lime with silica.

Hydraulic Limestone as before stated, consists of a mixture of carbonate of lime and silicate of alumina.

In these concretions the compounds composing them may replace each other to any extent; thus chert passes into flint (silica) or into chalk (carbonate of lime), owing to one compound or the other being in excess.

ON ICE-GROOVED ROCK SURFACES NEAR VICTORIA, VANCOUVER ISLAND; WITH NOTES ON THE GLACIAL PHENOMENA OF THE NEIGHBOURING REGION, AND ON THE MUIR GLACIER OF ALASKA. BY G. W. LAMPLUGH.

PART I.—GLACIATION NEAR VICTORIA, V. I.

Introduction.—During an enforced and unexpected stay of nearly a month in the town of Victoria, Vancouver Island, last autumn (1884), I spent some time in examining the glacial phenomena of the surrounding district. I did not then know if any work had been done in the neighbourhood, but afterwards found that more than one account of the glaciation of south-eastern Vancouver had been published, the most important being an excellent memoir in the Quarterly Journal of the Geological Society, Vol. XXXIV., p. 89 (1878), by Dr. G. M. Dawson, of the Geological Survey of Canada. But as the features are so striking and so far beyond what we see near home, I think another account of them is not only permissible but desirable, especially as the observations have been made from an independent standpoint.

In the following communication I have arranged, with very slight alterations, the notes and sketches which I made of some of the most remarkable instances of rock sculpture which came under my notice. I have added a few ideas suggested at the time or since by the study of them, in which, however, I have confined myself to matters of detail, and have not entered into broader questions as to the character of the glaciation over the whole region, as this has been very ably done by Dr. G. M. Dawson, in the above cited memoir, to which I would refer those who desire more extended information.

Geographical Features.—That I may be able to indicate the exact geographical position of the rock surfaces to which I am about to refer, I have prepared a ground-plan of the country and coast-line near Victoria, on which the places mentioned in the following notes are marked down (fig. 5). Within the area covered

by this plan the country, though flatter than almost any equal space within the limits of this rugged island, has an undulating, and often steep and broken outline, the solid rocks cropping out everywhere from under an irregular covering of drift in bosses of dimensions varying from a few square feet to several thousand yards. The highest point within this area is about 400 feet above sea-level, but the average height is, I should say, under 60 feet.

Fig. 5.—Map of Coast-Line near Victoria, Vancouver Island. Scale 1 inch to 4 miles, *reduced from the large map issued by the Land Commissioners.*

The position of the rocks and sections figured in this paper are indicated by the numbers.

The outline of this and all neighbouring shores is very irregular, the sea reaching everywhere in open bays or long narrow fiords far into the land. The channel, partially shown on the ground-plan, of which Victoria Harbour forms part, may be taken as an example on a small scale of much of the coast-line. This inlet extends westward for a further three miles beyond the limits of my map, or about six miles in all, rarely reaching the breadth of a large river, except

near its head where it again widens into a basin somewhat larger than that which forms Victoria Harbour.

The whole of this part of North America, from Puget Sound northward to Alaska,* is an area of depression, and the sea occupies deeply-excavated valleys which often run quite into the heart of the mountains of the Coast Range. A perfect network of fiords, straits, and islands is thus formed.

So little has marine erosion done towards the shaping of the land, that during the course of a voyage northward to Alaska along these narrow water-ways, I saw very few parts of the coast where if there was solid rock, the sea had as yet cut even a beach-shelf, though there were a few low sea-formed cliffs of till; and the steep mountain-slopes on either side were generally seen to pass unbroken beneath the clear waters of the fiords.

Glaciation.—In the area shown on the map, wherever the solid rock is seen, whether the outcrop be extensive or otherwise, it invariably shows signs of severe glaciation, even on the top of the highest hill in the neighbourhood, Mount Douglas, whose summit is 696 feet above sea level. On the rocky bosses inland these signs have been partially removed by weathering, so that only the broader features remain; but round the outer coast-line south and east of Victoria, where the waves are slowly stripping off the clayey covering, rocks can be seen in the low broken cliff showing the effects of glaciation, down to the most delicate and minute particular, as freshly as though the ice had just been removed from them; and as one passes over their smooth wave-like surfaces, every step reveals something worthy of close examination.

Of the rocks themselves, which are all metamorphic or igneous, I can give no accurate description, as my experience of igneous rocks has not been great enough to allow me to correctly describe or classify them. Dr. Dawson generally speaks of them as 'diorites' and 'felsites.' There seemed to me to be a great variety; some north and north-west of the city, closely resembled granites in appearance; whilst near Gonzales Point there were bedded rocks on the foreshore that looked liked baked and altered shales with

* And probably also southward to California.

ferruginous nodules; and in another place, in one of the recesses on the west side of Victoria Harbour, I noticed a mass of crystalline limestone.

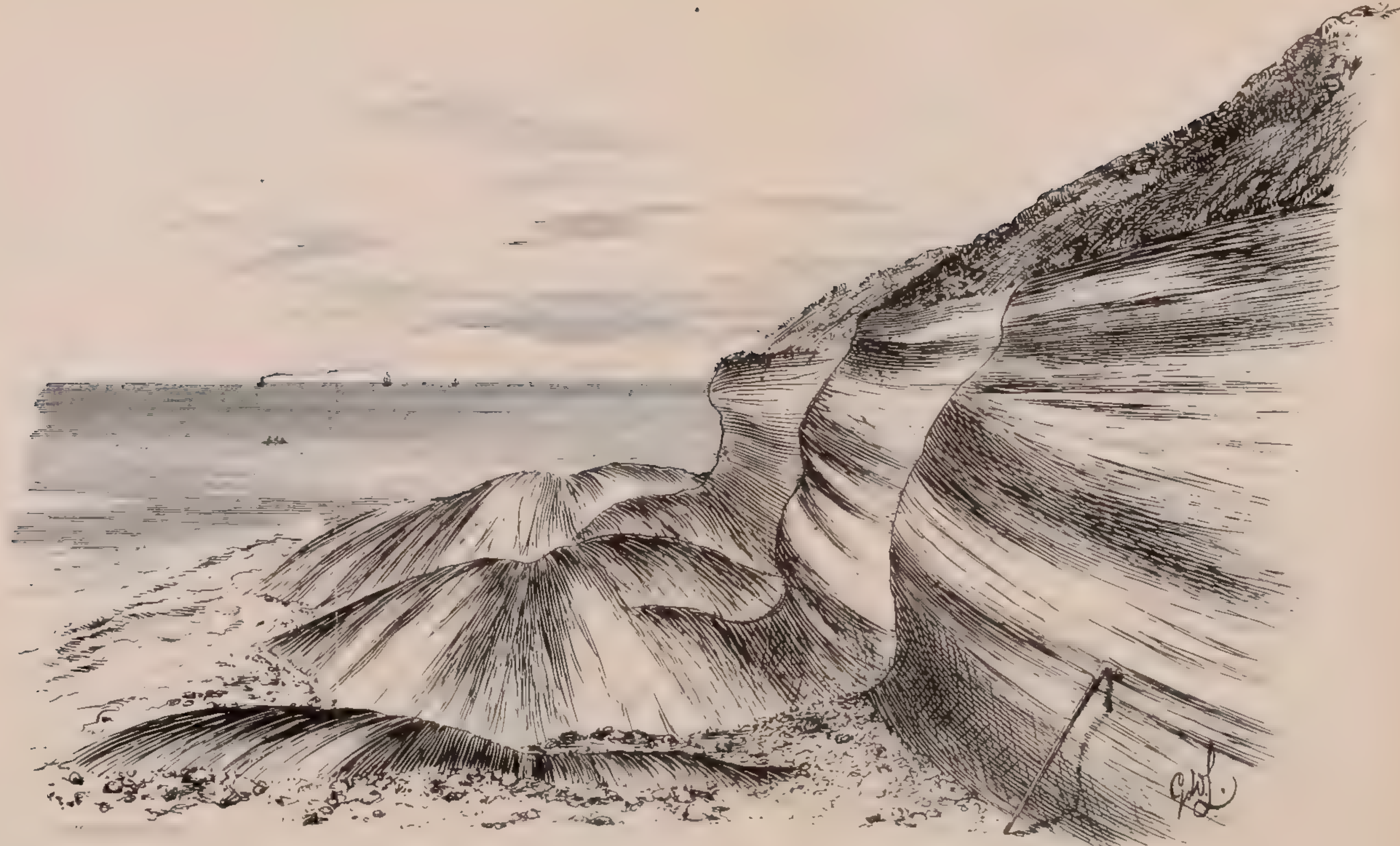
The deposit which covers the rock is usually a very hard sandy till, full of stones of small size, with a few large boulders; this is often tightly jammed into very narrow crevices in the rock. Where this till is of any thickness it often admits streaks of sand and gravel; and in some places these become so well developed as to form a lower division of the drift, though in the sections near Victoria the line of separation is not very clear (see Fig. 8). In a well which was being dug within the city limits on the Oak Bay Road, I noticed that the workmen were throwing out a fine tough grey clay without stones or other admixture from a depth of 18 feet; above, there was till of the usual character.

In some of these beds marine shells have been found.* I came across them near the middle of Shoal Bay, where they occur in abundance in clayey streaks amongst hard sandy till; and also in the excavation for the Government Dock at Esquimault three miles west of Victoria, where the shelly beds have been cut through. I availed myself of this latter opportunity to study these marine beds and collect their contents, on which I hope to make a separate communication. It seemed very curious to find delicate bivalves with valves united in beds of boulder clay immediately overlying rock surfaces which showed the application of enormous pressure; and I found it very difficult to believe that this boulder clay was the instrument by which the ice ground and polished the rocks, or—in other words—was its *moraine profonde*.

Glaciated Rocks.—As it is very doubtful whether I could raise a clear idea of the character of these glaciated rocks by means of words in anyone who has not seen them, or something resembling them, I have tried to do so by sketches reproduced from those taken on the spot; but as I am a poor draughtsman, I fear my attempt has not been very successful.

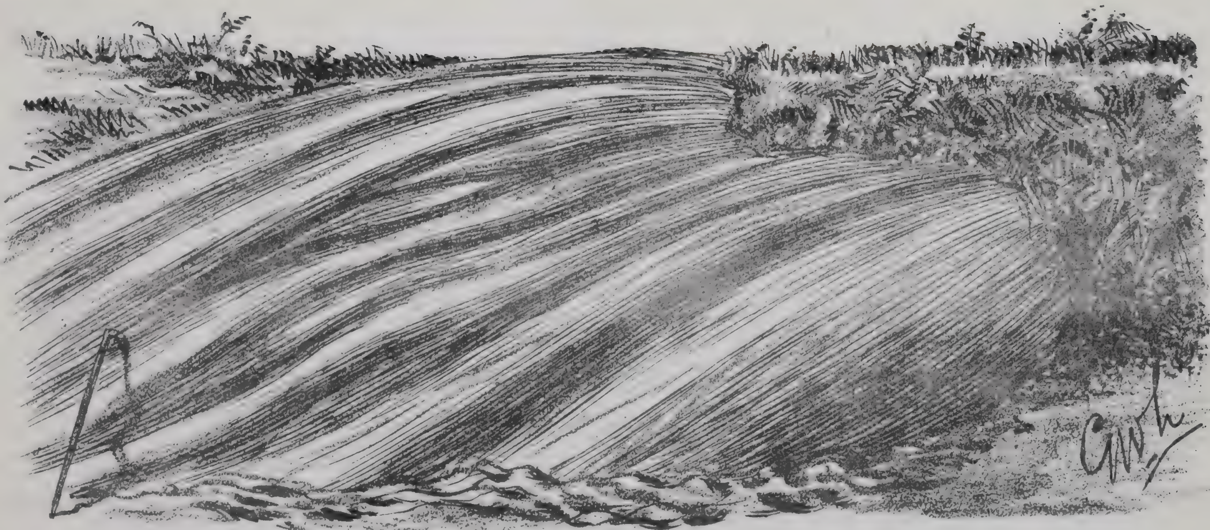
One of the most noteworthy features is the way in which vertical walls of rock have been striated and fluted apparently quite as severely as horizontal surfaces. Of this I have endeavoured to

* Supra. cit. p. 97; no locality mentioned.



Sketch of Bluff in a recess of the Coast S.E. of Victoria, V.I.

showing glaciation of a vertical wall of Basalt: Till and Gravel at the Cliff-top



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Fine Example of grooving and polishing of hard basaltic rocks on beach west of McNeil's Bay – first outcrop after passing the low cliff of Drift. Grooves 4 to 12 inches deep: 6 to 8 inches in breadth.

give an illustration on Pl. VI., where a vertical face of basalt has been horizontally striated, fluted, and undercut. Not only has this been the case where the wall has stood unprotected, but also where it has formed one side of a deep narrow gutter, such as those shown in Figs. 6 and 7. In all the cases which came under my notice, where

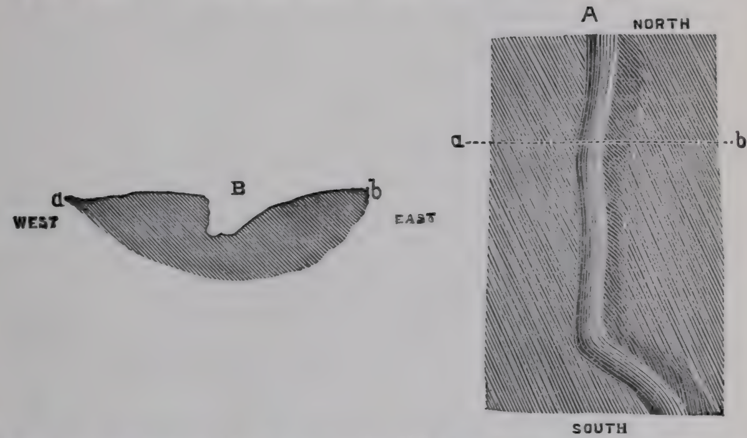


Fig. 6.—Ground-plan (A) and Section (B) of a glacial groove in close-grained quartzite (?) at Cemetery Point. Scale 1 inch to 20 feet.

A.—Groove running nearly north and south; 3 feet across at top, about 1 foot at bottom; 3 to 4 feet deep; about 30 feet in length as seen on the foreshore but is probably continued into the cliff; west side steep and almost overhanging, east side slopes at about 45°; striæ in groove run at a low angle with those on surface of rock.

B.—Section across the groove at *a. b.*

Shading on ground-plan shows direction of striæ.

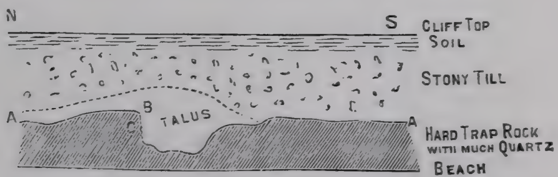


Fig. 7.—Section of Cliff near Victoria, V. I. (as indicated on Sketch-Map). Scale 1 inch to 45 feet.

A.A.—Beautifully striated and polished surfaces—grooved and bossed—running N. and S., nearly.

B.—Sharp angle where different sets of striations meet.

C.—Vertical face, polished and striated along its direction, nearly E. and W.; further back than section it is cut up into sharp grooves.

a gutter of this kind has been excavated in an approximately north and south direction, the west wall is very steep, sometimes vertical or even undercut, whilst the east side shows a more gradual slope, (see Figures). From this I at first inferred that the ice had moved

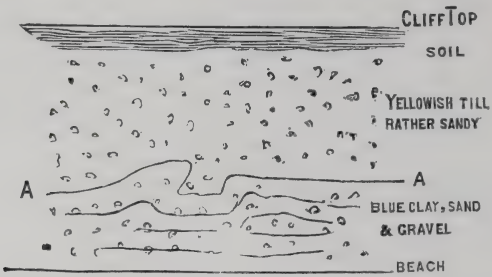
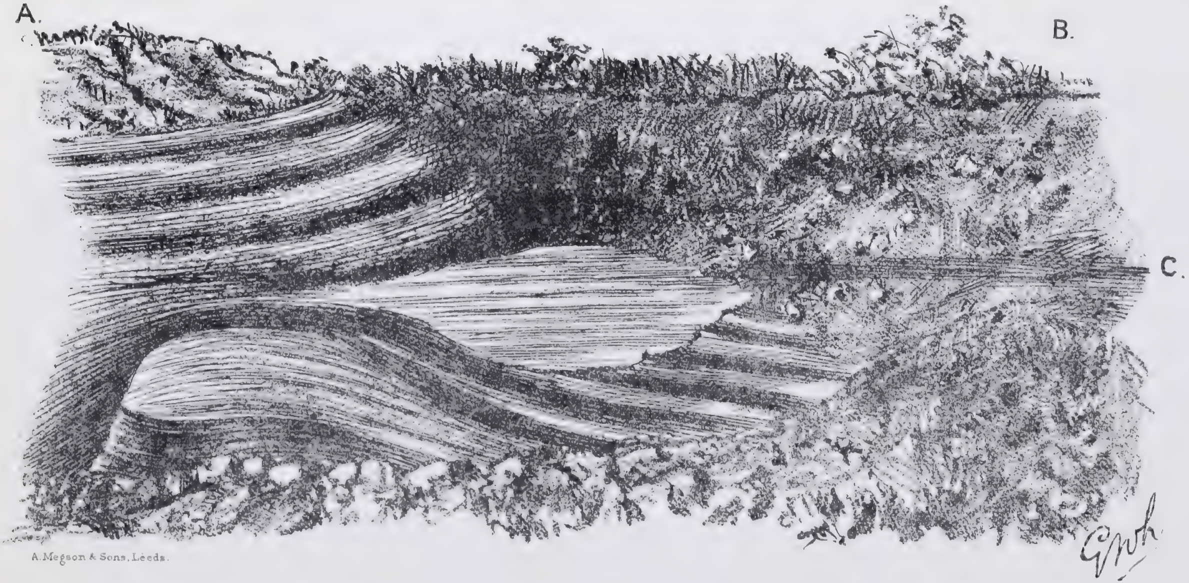


FIG. 8.—Section of Cliff about a quarter-of-a-mile east of above, showing division of drift deposits. Scale, 1 inch to 30 feet.

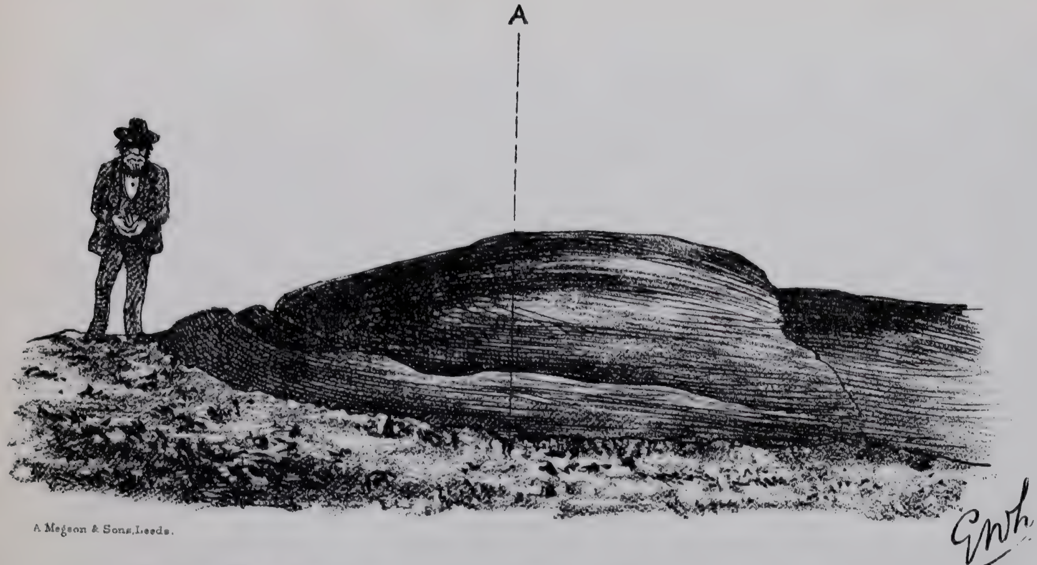
A.A.—Division, not very distinct, but yet clear enough to show contortion.

down into the channel from the east side, and borne heavily against the opposite slope by which it had been brought up and deflected, but the evidence of the striæ on the surrounding horizontal surfaces did not bear out this view, (see Fig. 6). Of course, it is possible that the bottoms of these gutters may bear the marks of an earlier glaciation. This view was strengthened by the way in which the two sets of striæ came in contact on the edges of these steep walls, where, instead of there being traces of a swerving of the horizontal set into the vertical, or *vice versa*, there is often a clear sharp angle, as shown in the sections in Figs. 6 and 7, and on Pl. VIII., as though the upper set had been eating into an already glaciated surface. But in other places there was evidence which tended to show that striation in varying directions did sometimes take place contemporaneously. The finest example of this was in the beautifully glaciated boss of which I give a sketch on Pl. IX., where a horizontal joint-plane in the rock has apparently deflected the erosive agent along its course in such a way as to cause a deep shelf or recess to be scooped out, which, in rounding the north-western shoulder of the boss, swerves considerably from the direction of the striæ on the surrounding surface, but which



Low Cliff on W. side of Rock Hill Point: grooving of Greenstone (?) and subsequent striation in another direction.

A *Weathered Outcrop of Greenstone. (?) – East.* B. *Cliff of Till, much slipped. – West.*
C. *Sandy streak in till.*



A Megson & Sons, Leeds.

View of West side of the boss of Felsite (?) exposed in the excavation at the Outer Wharf, Victoria, V.I. Height 5 feet, Length 30 feet.

A deep shelf is cut along the boss, commenced and determined by a joint-crack in the rock: it rounds the bluff after striking the joint, going about S.W. Till is jammed into the ledge.

Section across the Shelf at **A**. *Total width of Shelf 24 inches. Depth of minor grooves 4 to 6 inches. Overhang about 8 inches.*

runs out again and is lost before reaching the south end of the mass. Then again, though the striæ in the deep gutters often cross the general direction at a considerable angle, I could not find that they followed any regular system; so that, after all, I was not able to decide whether all the deep gutters were contemporaneous or not. I often found it very difficult, in a limited area, to get the true direction on such highly inclined and constantly changing slopes, and the bearings which I did take are not very exact as I did not allow correctly for the deviation of the compass; but in these detailed studies I do not think that this will be found of much consequence. Dr. Dawson gives * S. 11° W., as the direction of the glaciation over this part of the island, this being the average result of several hundred observations.

In wandering amongst rocks like these, so hard that the hammer was quite useless, and yet scooped and scored and dug into as though they were so many masses of cheese, one could not help being most forcibly impressed with a sense of the immense force with which the ice must have borne down on them; a force exerted not only on exposed surfaces but apparently with equal violence in channels so narrow that it is difficult to understand how the ice managed to stir after having been jammed into them. From the way in which the rock walls were scored and undercut, the tongue of ice must have been driven through them almost like a piston-rod. And yet although one had such palpable evidence on the one hand of the enormous potentiality possessed by the ice, the evidence was equally clear on the other, that the actual work performed by it had not been great; and that, though the surface had been so deeply scored, there had been no great mass of the fixed and solid rock removed. The general outline of the surface, the hills and hollows, and even the minor features—the narrow channels and isolated crags—seemed all to have belonged to the pre-glacial surface, and to have been in all probability the outcome of aerial erosion.

This important conclusion once arrived at, constantly recurred to me in examining these sections, till I came to regard even the gutters and deeper grooves as crevices which the ice had rarely done

* Supra cit.

more than deepen and widen. I first came to think in this way by seeing that although the north side of the hills and hillocks showed such thoroughly glaciated surfaces that in looking at them one would imagine glacial denudation to have taken place on a very large scale, yet the southern faces if steep, were rugged and broken, and seemed to have suffered nothing from ice (this may be seen on a small scale on Pl. IX. and Fig. 9), whereas if any considerable mass of rock had been removed, the whole outline of the surface would have been changed, and we should everywhere have seen the effects of glaciation.

Fig 9.—Section along west side of excavation at the 'Outer Wharf,' Victoria (Sept. 12th 1884), showing 'lee-side' of glaciated rocks.
Scale, 1 inch to 45 feet.

A.—Hard, fine-grained, grey, felsite (?) with veins of close dark basalt (?)

B.—Sandy till, with many small and a few large stones, hardened by pressure (?) and infiltration of iron from decaying vegetable soil into a rock-like mass in places, and sometimes jammed hard into small crevices of the rock; has a flakey stratified appearance, especially towards the top, which may be due to its having been split up by horizontal roots of trees and other vegetation.

C.—Magnificently scored, polished, and deeply grooved rock-surfaces—striæ running about parallel with section.

D.D.—Steep ridges of rock facing south, which are rough, unpolished, and broken.

Dr. Dawson had already noticed the same features, on which he remarks*—" With all this, however, there has been very little "general wearing-down of the rock-surface of the country; all its "main features, and in many cases even the most minute, are clearly "of preglacial origin." So that I have only followed in his footsteps in giving my own observations on this point; but it is a lesson which will bear repeating.

He also says: "This feature" (the rough southern faces) "is more marked than I have elsewhere observed, and would seem to indicate, even allowing that glaciers do not very rapidly abrade solid rocks, that the ice did not long rasp over this portion of the

* Supra cit., p. 95.

country, and possibly that it never extended much beyond this point." But with this I do not altogether agree; as I think there is evidence that the ice extended much lower in Puget Sound; nor do I think that a mass of ice which was certainly more than 700 feet thick could have accumulated rapidly in a region like this. It is more likely to have gathered slowly as in a basin from the mountains all round.

One has heard so much of the enormous erosive power of ice, that I, for one, had come to think of a strongly-glaciated district as one from which a great thickness of rock must necessarily have been removed. And I do not suppose I was singular in the supposition, for the writings of our leading glacialists all tend to strengthen this view. But I now find myself regarding the presence of much *roche moutonnée* in such a district as *primâ facie* evidence that the glaciation has probably been superficial; for I am inclined to think that a huge mass of ice in motion would not be likely either to initiate or accentuate minor inequalities of surface, but would on the other hand, have a constant tendency to level or remove them.

It is true that in the rocks under consideration there are many small seams and veins of harder material which stand out a little way on a glaciated rock-surface, but whatever their relative hardness may be, the limit of their protuberance is soon reached and the projecting portion ground off, so that the general outline is scarcely affected. And though, no doubt, it is to the mineral character of the rocks that the main features of the surface are due, the erosion seems to have taken place before, and not during, the passage of the ice.

It is for glacialists to decide how such a body of ice, whose very mass, as I understand it, presupposes in an area like this a slow process of accumulation, can have covered for a long time a region of this kind with such a partial and erratic expenditure of force.

I would also draw their attention to the cliff-section which I saw near the foot of the Muir Glacier in Alaska, described in the third part of this paper, in which a great mass of ice directly overlaid bedded sands and gravels without disturbing them.

In conclusion, I must acknowledge that I have made very poor use of extremely interesting material, and if it were only in my

power to spend a few hours now on these sections over which I was wandering at this time last year for day after day, I could bring much more valuable results before you. In going through my scanty notes many interesting problems have presented themselves to me, which might easily have been solved by a short review of the locality. But the purpose of this paper will be served if it recall attention to the fact that the Pacific coast of North America, northward from the Columbia River, forms a most delightful, interesting, and nearly unbroken field for the study of almost every phase of glacial phenomena.

Part II.—Notes on the Glacial Phenomena of the Neighbouring Region

It may be well to take this opportunity to publish a few scattered notes on the glaciation of various points in the Pacific Coast region, which may serve as indications to future observers.

Port Townsend, W. T.—At Port Townsend, Washington Territory, about 35 miles S.E. from Victoria, there is a fine cliff-section of glacial beds 60 to 80 feet in height, consisting of till overlying cross-bedded sands and gravels; and I was told by a resident that a seam of peat could be seen in the cliff a little distance to the north of the town, but I had not time to go there. If the peat occur in the position indicated, it must be in glacial beds.

The Fraser Valley.—Amongst the many excellent sections I observed on the mainland of British Columbia in walking down the Fraser Valley, was one on the then unopened line of the Canadian Pacific Railway where it skirts the mountain side after crossing the Harrison River. Here, in a cutting, morainic gravel overlaid bedded silts which contained a few crushed shells. These are undoubtedly marine. This spot must be a considerable height above sea-level, and the presence of marine remains here indicates an extensive submergence of the Fraser Valley in glacial times.

Vancouver Island.—In walking across Vancouver Island on the forest trail from Nanaimo on the east coast to Alberni on an inlet of the west, I noticed a great accumulation of glacial debris, chiefly morainic, between the mountains and the sea on the east side of the island all the way to the mouth of the Qualicum River where my

trail turned inland; and at Alberni I saw a true till in the river banks, but did not come across any well-glaciated surfaces.

Alaska.—In a voyage northward to Sitka, Alaska, wherever the steamer allowed us to land I saw well-marked evidences of glaciation, either in the form of scattered blocks, glaciated surfaces, or morainic material. The best examples of the last were seen at Metlakahtlah and Fort Wrangel. The glaciated surfaces do not seem to have retained their markings nearly so well as in the region further south as one might expect from the severer winters and greater rainfall; but at Sitka, on tearing away a thin covering of sods from the hillock of basalt on which the old block house stands, I laid bare a beautifully scratched surface, though the exposed rock on the slopes of the mound only showed the broader features of glaciation.

PART III.—THE MUIR GLACIER OF ALASKA.

This glacier is a glorious mass of clear blue ice which comes down to the sea in a narrow fiord in lat. 59° N., opening into the Chicoot Inlet. It ends in an unbroken precipice crowned with pinnacles which stretches completely across the fiord, being three miles long, and from 250 to 350 feet in height. Huge masses are detached from this cliff at short intervals and go crashing down into the sea, filling the fiord with floating ice, and causing a heavy ground swell which runs in breakers on the beach. These breakers have cut the cliff-section which I shall presently describe.

At the time of my visit, Aug. 9th, 1884, when the waters of the bay were quiet, strong springs of milky water could be seen rising up through the sea near the foot of the ice. Similar springs gushed out in many places on the gravelly slopes of the eastern moraine, between the glacier and the mountains, sometimes coming up through an unknown thickness of clear ice, depositing in some cases masses of pasty clay in hollow places amongst the gravels, which formed dangerous sloughs. This water-system is quite distinct from the surface-drainage of the glacier with which it sometimes mingles: the upper waters even when crossing surface-moraine are always brilliantly pure and bright.

On the sandy beach of the eastern shore, within a few hundred feet of the ice cliff, I saw a small patch of blueish-grey

clay with stones, closely resembling till, and another small patch without stones. These out-cropped from the foot of a cliff of well-bedded and water-worn gravel and sand 40 feet high, which extended close up to the face of the precipice of ice ; the gravel was overlaid at the time of my visit by a flange of ice about 60 feet thick. The ice seemed to flow down from the main mass of the glacier; though as there was only a very narrow strip of beach, I could not get far enough back from the precipice to see clearly the connection between them. The gravels and ice together formed an almost vertical face of about 100 feet, yet the gravels showed no traces of disturbance. The ice was very full of debris and seemed to come from that part of the glacier which bore the lateral moraine. It thinned out rapidly after leaving the main-body, but had evidently once extended much further than when I saw it, for it tapered away into a loose deposit of stones and clay which capped the gravels to the end of the section. This deposit cut down into the gravels in places; but there were no traces of disturbance at the junction, which was one of clear sharp erosion.

The glacier, which is diminishing so rapidly that an island now above a mile distant is said by old Indians to have been embedded in the ice during their recollection, has shrunk away from the mountains on the eastern side for some distance, forming a triangular hollow whose base-line on the beach I should estimate had a length of about half-a-mile, and whose greatest length could not have been far short of two miles.

In this hollow were curious ridges of sand and gravel mixed with rough boulders, which reminded me of kames. These generally ran roughly parallel to the glacier, but were crossed and confused in places by other less regular masses. I found ice hidden under the gravel in some of these ridges, and think I understand how they were formed, but as it is my desire to avoid all theory in these brief notes, I will not now enter further into their origin.

I may here remark that amongst the very great number of boulders seen during the day, I only noticed one which showed glacial striæ. This was on the surface of the moraine not far above the beach. Under the guidance of a western gentleman who had

made the journey before, I reached the upper surface of the glacier by passing diagonally along the eastern moraine. The ice was at first hidden by boulders, gravel, and disintegrated granite, but we soon reached clear smooth ice. This was at first very deeply crevassed, and extended backward with a strong slope, so that at the end of the first two miles, we could not have been much less than 1,000 feet above sea-level. We had now reached the crest of the slope, and looked, as it seemed to me, slightly downwards into a wide basin of ice which was probably six or eight miles across, and stretched away up the valley to some mountains which we estimated were not less than 40 miles distant.*

From the mountains flanking the valley numberless feeders of ice poured in, so that the basin before us resembled a storm-tossed lake, the steep broken slope we had just passed being the comparatively narrow outlet by which it discharged into the sea.

After passing the crest we found that the crevasses were no longer open, their sides coming together some distance below the surface so as to form pools of water of most delicate and lovely blue tints deepening with the depth of the water.

Travelling was now not so dangerous, though the surface of the ice being made up of fantastic hummocks, was extremely rough and irregular.

Three or four miles ahead of us a large island of whiteish rock cropped out high above the ice.

We now changed our direction and struck out across the glacier. There were still no open crevasses; but very deep water-pools and tall steep hummocks, which were often very difficult to pass, shared the surface between them. We crossed a moraine of rapidly wasting granite blocks about a mile from the edge of the ice, and penetrated 1,000 yards or so further, and then found it was time to return to the ship. The ice seemed to rise before us in long broken ridges running

* In "Nature" for June 18th, 1885, there is a paragraph copied from a San Francisco paper stating that the glacier is about 150 miles long, and ends in cliffs 500 feet high, but I think these are gross exaggerations. The cliffs were said to be 450 feet in height by the officers of our ship, but by comparing them with the section I have described on the eastern shore, which could be tolerably closely estimated, I came to the conclusion that the walls range from 240 to 350 feet, the latter being a very liberal estimate.

parallel with the length of the glacier, and I pressed on alone to the crest of one of these which was not far ahead of us. Looking forward from this point, though the ice seemed to become more and more rugged, I still could not see any open crevasses, and think it might have been possible to cross the glacier.

Here, in the midst of beautifully clear ice, far away from any trace of moraine, I noticed some curious reddish-yellow stains, and in looking for the cause, found in one place a clayey-looking mass of gritty matter of the colour of rusted iron. I brought part of this away with me, and think it may possibly be the remains of a decomposed meteorite. Some of the matter is now in the hands of Mr. T. Davis of the British Museum, who has promised to examine it.

We then hurriedly, and for my own part very reluctantly, returned to the ship, having probably gone as far on the ice as any of our predecessors.

This is the first glacier I have visited, and I brought away the impression that on the whole it was easier to give explanations of glacial phenomena before I had seen ice. Perhaps, if I could have spent weeks instead of hours there my opinion might have been different.

NOTES ON THE YOREDALE POLYZOA OF NORTH LANCASHIRE.

BY GEORGE ROBERT VINE.

I have already, in three separate papers,* laid before the Yorkshire Geological Society, notes on the Carboniferous Polyzoa of Derbyshire and Yorkshire. I have now to draw the attention of members to remarks on Polyzoa found in the neighbourhood of Furness Abbey, said to belong to rocks of Yoredale age. Before, however, I give a description of the species, it may be well to offer a few remarks on the Palæontology of the Yoredale rocks, and also to give some account as to how the material about to be described came into my possession.

In 1884, Mr. James W. Kirkby, F.G.S., sent me a sample of Polyzoa pickings from some Carboniferous shale washings which he

* 1881, 1883, 1883, Proc. York. Geol. Soc.

was searching for Entomostraca.* I saw directly that many of the examples were of similar age, and probably of the same horizon, as my Hurst and Richmond species, but in addition there were several new forms previously unknown to me, either from the Yorkshire, Northumberland, or Scotch shales. In drawing Mr. Kirkby's attention to these facts he gave me full permission, either to describe, or make notes on the material in my possession, offering at the same time to supply me with other examples whenever they turned up. Since then I have had a very fair supply from some one or other of the following localities:—

1. Gleaston Castle	—Yoredale Rocks		—Near Barrow.	
2. Little Urswich	,,	,,	,,	Dalton (?)
3. Holker Park	,,	,,	,,	Cark, W.L.
4. Scales Green (very poor)		,,	,,	Furness.
5. Kent's Bank	—Scar Limestone		—Morecambe Bay.	
6. Humphrey's Head†	,,	(?)	,,	,,
7. Arnside	,,		Westmoreland.	

It is impossible for me to offer any original remarks on the rocks in question, as my studies are confined more particularly to Palæontological than to questions purely geological. Yet at the same time I always endeavour to make myself fully acquainted with the horizons of my fossils, especially so whenever I am dealing with Carboniferous forms. There are, however, peculiar *facies* amongst all Palæozoic fossils that seem to separate species from almost similar forms found in rocks of later age—such as Mesozoic or Cainozoic—but the Polyzoa of the Carboniferous formation especially, are remarkable for a constancy of facial feature, whether found in American or in British rocks. I regard, therefore, the following remarks of Mr. R. Etheredge in one of his presidential addresses, as due rather to a paucity of lists, than to a paucity of a Polyzoa fauna of Yoredale age at least.

"The Carboniferous Bryozoa (Polyzoa) as a group, constitute by far the largest series in any division of the Palæozoic rocks.

* See paper on Carboniferous Ostracoda; Prof. T. Rupert Jones and James W. Kirkby, Esq., Geol. Mag., Dec., 1885, pp. 535-541. The authors give a list of Entomostraca found in the Shales of North Lancashire, both of the Scar and Yoredale Rocks: also Notes on the Foraminifera (Vine), "Naturalist," November, 1854.

† The position of the shales at this locality is not clear.

Seventy-seven species range through the three lower horizons of the Carboniferous series; seventy-four belonging to the true Carboniferous Limestone, twenty-eight to the lower Limestone shales, and four to the Calciferous series; *not a single species passes to or occurs in the Yoredale*, Millstone Grit, or either one of the three divisions of the coal measures. *The whole group essentially belongs to and characterises the Calcareous rocks and shales at the base of the formation*."*

If this be true, then, Palæontologically speaking, we have no Yoredale rocks, for not only Polyzoa but many other organisms as well, are quite common to the Calcareous, and to the Yoredale series. It will, however, be far more advantageous to science to keep the horizons of fossils distinct, than to lump the whole of the divisions as members of the Calcareous divisions only, irrespective of local changes.

I have already worked out the Polyzoa of Northumberland,† some of the rocks of which are of Yoredale age, whilst other rocks in the same district belong to the Lower Limestone series; and Mr. John Young of the Hunterian Museum of Glasgow, and the members of the Scotch Geological Survey, have furnished fair, if not complete lists of Upper and Lower Carboniferous forms, and it is to be hoped, that before long we shall have from the pen of Mr. G. W. Shrubsole complete lists of North Wales Carboniferous Polyzoa. Lists of American species are not completed. In the following table of the more generally known forms, only described species are noted.

EXPLANATION OF THE TABLE.

1. Gleaston Castle—Yoredale Rocks—Near Barrow, W. Lancashire.
2 Little Urswich „ „ „ Dalton, „
3. Loc. ? „ „ „ Loc. ? „
4. Holker Park „ „ „ Cark „
5. Hurst „ „ Yorkshire.
6. Various Localities „ „ Northumberland.
7. Various Localities—Scar Limestone—Derbyshire and Lancashire. Indicated by D. & L.
8. Various Localities—Lower Limestone Shales—Scotland.
9. Various Localities—Upper Limestone Shales—Scotland.
10. Various Localities—Carboniferous Limestone Shales—America.

* Presidential Address, Quart. Jour. Geol. Soc., Feb., 1881, p. 185.
† "Naturlist," 1884 and 1885.

Carboniferous Polyzoa.

Table:—Showing the range of Carboniferous Polyzoa in the Yoredale rocks.

		Yoredale.							Scot.			
		Lancashire.				Yorkshire.	North-umberland		Low. Sh.	Up. Sh.	America.	
	Group A.	1	2	3	4	5	6	7	8	9	10	
	Fenestellidæ.											
	Fenestella, *Lonsd.*											
1	plebeia, *M'Coy*		×		×	×	×	×	×	×	?	
2	crassa, *M'Coy*											Wales.
3	polyporata, *Phillips* ...					×		×		×		
4	nodulosa, *Phill.*	?			× ?	×	×		× ?	× ?	?	
5	tuberculocarinata, *Eth Jun*		×		×					×		
6	membranacea, *Phill.* ...					×					?	
7	halkenensis, *Shrubsole* ...											Wales.
	Ptilopora, *M'Coy.*											
8	pluma, *M'Coy*											Ireland.
9	*var.* Phillipsii, *Vine* ...							D.				
	Pinnatopora, *Vine.*											
10	bipinnata, *Phill.*					×						
11	gracilis, *M'Coy*			× ?								
12	grandis, *M'Coy*			× ?								
13	pulcherima, *M'Coy* ...											
14	elegans, *Y. & Y.*... ...		×			×			×	×	?	
15	aspera, *Y. & Y.*				?		?		×			
16	recticarinata, *Y. & Y.* ...	×	×		×				×	×		
17	? *var.* flexicarinata, *Y. & Y.*	×	×		×	×	×		×	×		
18	retroflexa, *Y. & Y.* ..	×	×	×	×				×	×		
19	robusta, *Y. & Y.*... ...		×						?	×		
20	laxa, *Y. & Y.*						×		×			
21	pluma, *Phillips*					×						
22	ornata, n. sp.			×	×							
23	simplex, n. sp.				×							
	Group B.											
	Septopora, *Pront.*											
24	biserialis, *Swallow* ...										×	= (Synoc-
25	carbonaria, *Eth. Jun.* ...									×		ladiæ
26	scotica, *Y. & Y.*									×		Authors).
27	fenestrelliformi, *Y. & Y.*								×	?		
	Diploporidæ.											
	Diplopora, *Young & Y.*											
28	marginalis, *Y. & Y.* ...	×			×	×	×	×	×	×		
	Acanthopora, *Y. & Y.*											
29	stellipora, *Y. & Y.* ...	×	×	×	×	×	×		×	×		
30	*var.* spinosa, *Y. & Y.* ...	×		×	×	×	×		×	×		
	Actinostoma, *Y. & Y.*											
31	fenestrata, *Y. & Y.* ...	×			×	×			×	×		

CARBONIFEROUS POLYZOA (Continued).

		Yoredale.							Scot.			
		Lancashire.				Yorkshire.	North-umberland		Low. Sh	Up. Sh	America.	
		1	2	3	4	5	6	7	8	9	10	
	Polyporidæ, *Vine.*											
	Polypora, *M'Coy.*											
32	verrucosa ? *M'Coy* ...				×	×	?					Ireland.
33	papillata ? *M'Coy* ...											Ireland.
34	tuberculata, *Prout* ...										×	
35	tuberculata ? *Young & Y.*								×	×		Scotch form.
36	biamarca, *Keyserling* ...										×	
37	laxa, *Phillips*					×		D.				
	Thamniscidæ.											
	Thamniscus, *King.*											
38	rankinei, *Y. & Y.* ...									×		
39	carbonaria, *Vine*							D.				
40	gracilis, *Vine*	×										
	II. Cryptostomata, *Vine.*											
	Rhabdomesontidæ, *Vine.*											
	Section A.											
	Rhabdomeson, *Young & Y.*											
41	gracile, *Phill.*	×	×		×	×	×	×	×	×	?	
42	rhombifera, *Phill.* ...	×			×	×			×	×		
	Section B.											
	Rhombopora, *Hall.*											
43	persimilis, *Ulrich.* ...	×		× ?		×					×	
44	similis ? *Phill.*			×								
45	vinculariformis, *n. sp.* ...	×										Scotland, J. Young's cabinet.
	Cystodictyadii. *Ulrich.*											
46	parallela, *Phill.*	×		×	×		×		×	×	?	
47	raricosta, *M'Coy*			×	×	?			×	×		
	Hyphasmaporidæ.											
	Hyphasmapora, *Eth. Jun.*											
48	Buskii, *Eth. Jun.*... ...	×		×	×	×	×		×	×		
	Streblotrypa, *Ulrich.*											
49	Nicklisii. *Ulrich*	×			×	×				?	×	Scotland, J. Young's cabinet.
50	minuta, *Vine*	×			×					?		
	Goniocladiâ.											
51	cellulifera, *Eth. Jun.* ...					×			×	×		

Class POLYZOA, Busk, Hincks, &c.

= *Bryozoa* (pars) Ehrenberg: *Bryozoa* (pars) of American authors, *Bryozoa*, Ruess, Manzoni, Rœmer, Waters.

Order GYMNOLEMATA, Allman.

Sub-order, CYCLOSTOMATA, Busk.

Zoœcia tubular, with a plain inoperculate orifice. Marsupia and appendicular organs wanting.

Family FENESTELLIDÆ (restricted).

Group A.

1883. Fourth British Association Report on Fossil Polyzoa (mihi)

1884. Naturalist, p. 60, 1885, pp. 208-214 (Northumberland Polyzoa).

Zoarium forming large and small fenestrated or non-fenestrated expansions. *Zoœcia* arranged biserially in the branch, tubular, but (in section) slightly truncated at the distal extremity; orifice circular, opening on one side only.

Genus FENESTELLA (restricted).

1. FENESTELLA PLEBEIA, M'Coy, Syn. Carb. Foss., Ireland, pl. 29, fig. 3.

Fenestella plebeia, Shrubsole, Quart. Jour. Geol. Soc., May, 1879, p. 278; Ibid May, 1881, p. 179.

Fenestella plebeia, Vine, Proceed. York. Geol. and Polyt. Soc., Vol. VII., 1881, p. 336; Ibid Vol. VIII., 1883, p. 164.

As Mr. G. W. Shrubsole gives no fewer than fourteen synonyms of the above species, the student should consult the papers referred to.

There are several fragments of *F. plebeia* in the different shale washings of North Lancashire, some have very marked features, while others belong to common forms of this widely distributed species. One noticeable fragment has a well formed, rounded keel, but without tubercles, and slightly different from the Scotch or even Yorkshire *F. plebeia*. Other fragments on the shale show the reverse aspect only, and these are of ordinary character.

Localities and Horizon: Yoredale; Holker Park, Little Urswich. Scar Limestone; common.

2. FENESTELLA TUBERCULO-CARINATA, Etheridge, Jun.
= *Fenestella* sp. Eth. Jun., explanation of sheet 23, Memoirs of Geol. Survey, Scotland, p. 101.
= Fenestella arctica, Salter, *var. Scotica*, Eth. Jun. Ann. Mag., Nat. Hist, Vol XX., p. 31, July, 1877.
= ,, *tuberculo-carinata*, Vine, Proceed. York. Geol. Soc., Vol. VII., p. 335.
= ,, *tuberculo-carinata*, Young. Trans. Geol. Soc., Glasgow, May, 1882, pp. 182-188.

Zoarium forming large and small expansions of unknown dimensions, but over four inches in diameter, even in its imperfect condition, *Interstices* (branches) carinated, and occasionally bifurcating, with large zoœcial aperture at each angle of bifurcation. *Dissepiments*, short, alternate, normally thin, but thickening according to age. *Fenestrules* either hexagongal or quadrangular; measured over large surfaces where the characters are pretty constant, the number of fenestrules to six lines, are in length sixteen, in the breadth about twenty three. *Carina* (keel) zigzag, faintly conspicuous, or well rounded, bearing on the surface from three to five blunt or finely tapering spines to each fenestrule. *Zoœcia* large, orifice large with well-developed peristome, three cells—generally a constant character—on either side of the fenestrule, the middle one occasionally indenting the margin. *Reverse* granular or finely tuberculated, with a prominent—slight or well rounded—tubercle at each corner of the quadrangular, or slightly hexagonal fenestrule. *Spiniferous processes*, very robust.

Locality and Horizon: Yoredale; Holker Park, Little Urswich.

This species—though not abundant in the Yoredale shales of either Yorkshire or Lancashire—has all the characters of the best preserved of the Scotch specimens. The spiniferous process—either attached or broken off—have special features, and for the size of the species are very robust, and the hook-like prolongations are always turned towards the Zoarium. As none of the authors referred to in the above synonyms, have drawn up full descriptions of this well marked type, I have availed myself of remarks made by Mr. John Young, and by Mr. Robert Etheridge in the details furnished.

3. FENESTELLA NODULOSA, Phillips.

= *Retepora id.* Phill. Geol. Yorks., pl. I., figs. 31-33.

Fenestella bicellulata, Eth. Jun. Mem. Geol. Surv., Scot., Sheet 23, p. 101.

= ,, *frutex*, M'Coy Syn. Carb. Foss., Ireland, pl. 10.

= ,, *Popeana*, Prout, Trans. Acad., St. Louis, p. 220.

= ,, *subreteformis*, Prout, op. cit. p. 230

= ,, *nodulosa*, Shrubsole, Quart. Jour. Geol., Soc. May, 1879, p. 280, May, 1882, p. 183.

= ,, *nodulosa*, Vine, Naturalist, Sept., 1885, p. 314.

Several fragments belonging to this species are rather abundant in the shales, and although Mr. G. W. Shrubsole at one time regarded *Actinostoma fenestratum*, Young & Young, as the perfect form of this species, he does not give this as a synonym in his later paper. It is to this species, however, that Mr. Shrubsole noticed that *Palæocorynæ* were more frequently attached, "for out of ninety-seven specimens of *Palæocorynæ*, eighty-five are either attached to polypite-face of *F. nodulosa* or associated with it, while twelve are only free and unattached."*

Locality and horizon: Yoredale; Gleaston Castle, Holker Park.

4. FENESTELLA POLYPORATE, Phill. Geol. Yorks., pl. I., figs. 19-20.

I have not the least doubt but that specimens belonging to this species may be found in the Lancashire shales; I have only a few small fragments in my collection.

Locality and Horizon: Yoredale; Holker Park. Hurst.

5. PALÆOCORYNE RADIATUM, Duncan & Jenkins.

6. ,, SCOTICA, Duncan & Jenkins.

Phil. Trans., Vol. CLIX, p. 693, 1869.

Quart. Jour. Geol. Soc., Vol. XXIX., pl. XIV., 1873.

The detached parts of the zoarium of *F. nodulosa* belonging to this group of "organisms," are very abundant in the North Lancashire shales. They are well preserved and very fine. As, however, Prof. Duncan was the first to work out the group, I have only given the references to the original papers, because, however the forms may be regarded at the present time—the admirable

* Quart. Jour Geol. Soc., May, 1881, p. 185.

details and illustrations furnished by Dr. Duncan and Mr. Jenkins, will always be regarded by special workers as most unique.

Localities and Horizon: Yoredale; Holker Park, Gleaston Castle, Little Urswich; in the shales of Northumberland and Haltwhistle; Hurst. Common in all localities wherever *F. nodulosa* is found.

Genus PINNATOPORA, *Vine.*

= Glauconome sp. of authors.

1883. Pinnatopora n. gen, Vine, Brit. Assoc. Rep. Foss. Polyzoa.
1884-5. Pinnatopora, Vine, Naturalist, pp. 60-315.

Zoarium pinnated, with secondary branches, likewise pinnated, but rarely fenestrated by the inosculation of pinnæ. *Zoœcia* tubular, arranged biserially, originating immediately beneath, or in a line with the keel. *Carina* feebly developed in some, well developed in other species, ornamented with the bases of spines or plain. *Oœcia* (?) an inflated cell.

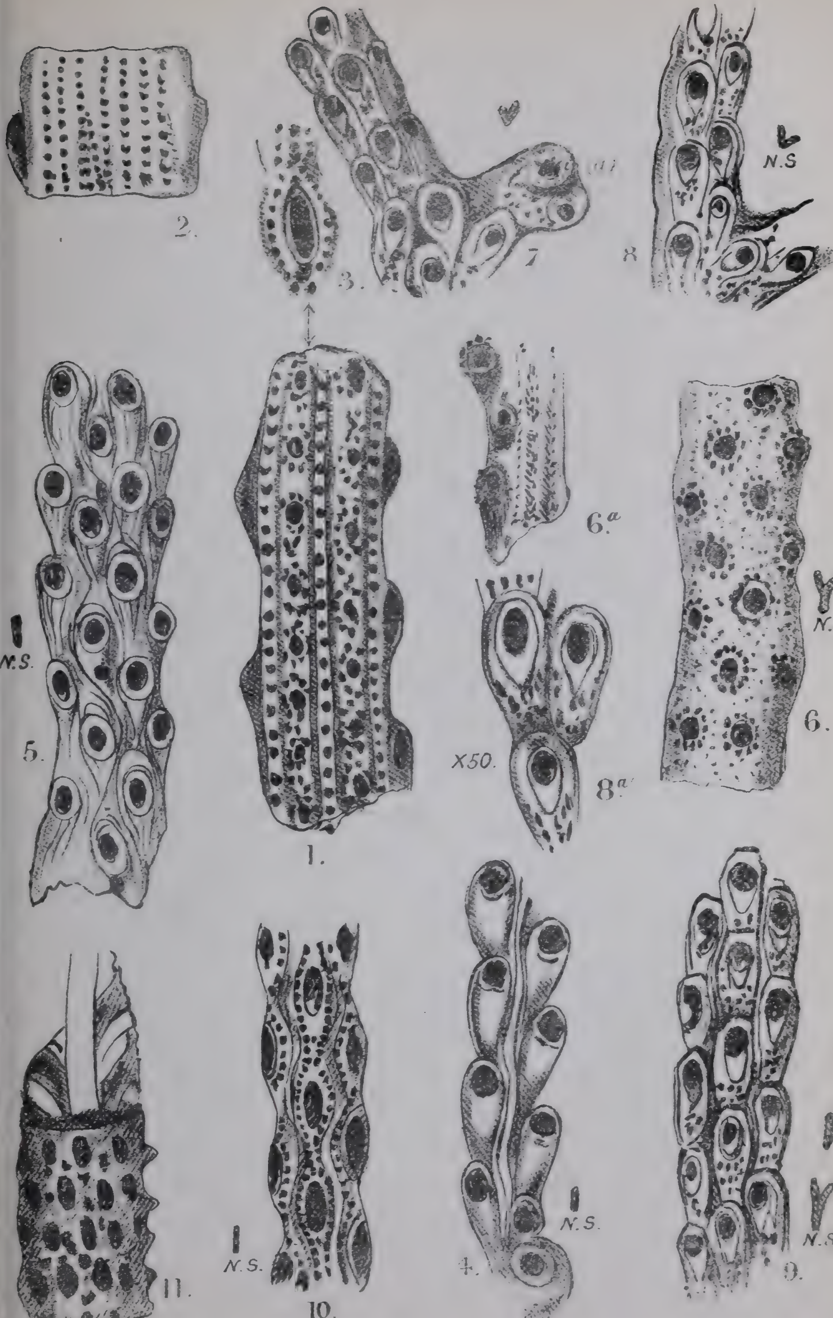
7. PINNATOPORA ORNATA n. sp., p. X., figs. 1, 2, 3.

Zoarium consisting of a broad central branch with faintly devoloped pinnæ, but of unknown dimensions. *Central branch:* the superficies of this are unlike any other ordinary species of *Pinnatoporæ*, ornamented with three keels, a central one, and one on either side but near to the margins, beyond which the lateral pinnæ are faintly developed. *Zoœcia* oval, or slightly elongated, alternate, arranged in lines on either side of the central keel; the margins of the zoæcia are ornamented with prominent, but delicate tubercles, from ten to fourteen. and in some cases sixteen in number, with occasionally an intercallated tubercle just within the margin of the orifice on the distal part. *Carina*, central one angular or slightly rounded, occasionally depressed with one or more rows of contiguous tubercules, delicate; lateral keels similarly ornamented; average number of tubercles in a row between the pinnæ, from twelve to eighteen. *Reverse* of branch rounded (normal) ornamented with from eight to ten rows of feebly tuberculated ridges, sometimes very prominent. *Pinnæ* (?) in their earliest stage fluted.

Horizon: Yoredale rocks of North Lancashire.

Localities: Holker Park, Gleaston Castle.

This most beautiful species I have only, as yet, found in the



YOREDALE POLYZOA.

Megson & Sons, Leeds.

North Lancashire shales, where it is tolerably abundant, especially at Holker Park. In a conversation that I had lately with Mr. John Young at the Hunterian Museum, Glasgow, he assured me that he had never met with the species in any of the Scotch shales, and I have no examples among my American Carboniferous Polyzoa with which I can compare it.

8. PINNATOPORA RECTICARINATA, Young.

= *Glauconome id.* Y. Proc. Nat. Hist. Soc., Glasgow, 1880, pp. 257, 259.

Zoarium robust or delicate, main stem and pinnæ strongly carinated. *Zoœcia* oval, rather more than their length apart, one at the base of each pinnule, and one in the space between; peristomes prominent, surrounded with close set tubercles; cells on the main stem and pinnules alternate. *Carina* straight, delicately tubercled, close set. *Pinnules* rather more than a line in length, opposite or slightly sub-alternate. *Reverse* flat or slightly rounded, and ornamented with from three to four rows of granulated striæ.

Horizon: Yoredale; but widely distributed in the English and Scotch shales.

Localities: Holker Park, Gleaston Castle, Little Urswich. Hurst.

In the peculiar ornamentation both of the face and of the reverse, this widely distributed polyzoon approaches the nearest to the *P. ornata* as described above. There is, however, no possibility of confounding the two species. This form is rather abundant in the Lancashire shales, but it is not by any means a common form in the English shales generally.

9. PINNATOPORA FLEXICARINATA, Young & Young,

Glauconome id. Y. & Y., Proc. Nat. Hist. Soc., Glasgow, March, 1875, pl. II., figs. 1-7.

= *Glauconome aspera*, Vine, Proc. York. Geol. Soc., 1881, p. 334, pl. XVI., fig. 3.

The present species is distinguished from *P. recticarinata* by possessing a "broad prominent mesial ridge, which undulates regularly from side to side, following the alternations of the cells." It is by no means so common as the above, yet Mr. Young suggested that probably *P. recticarinata* may be only a variety of

the present form. I think, however, that the two may be regarded as distinct species.

Horizon: Yoredale (not unfrequent in the Scotch Lower and Upper Shales).

Localities: Gleaston Castle, Little Urswich, Holker Park, W. Lancas. Hurst, Yorkshire.

10. PINNATOPORA RETROFLEXA, Young & Young.

= *Glauconome id.*, Y. & Y., Proc. Nat. Soc., Glasgow, 1875, pl. II., figs. 8-10, pl. III., figs. 11-13.

= *Glauconome id.*, Vine, Proc. Geol. Soc., Yorks., Vol. VII., p. 335.

Zoarium erect and robust, branches short, sub-alternate, bipinnate, branches at wide intervals, obverse finely granulated. *Zoœcia* on the stem longer than broad, alternate, their own length apart, one at the base of each branch, and one in the interval, partly hidden on the inner side by a keel, and bounded on the outside by a prominent peristome. *Carina* gently rounded, prominent, one third the diameter of the branch, and bearing several small tubercles. *Reverse* face of the branch evenly rounded and finely granular.

Localities: Yoredale; Gleaston Castle, common; Little Urswich.

The retrospect aspect of the pinnæ of this species is a really good and constant character, and generally speaking it is almost impossible to mistake this for any other species of Carboniferous Polyzoa. It is very abundant in the lower shales of Scotland, and fairly abundant in the English shales both of Lancashire and North Lancashire, but not so abundant in the Northumberland shales.

11. PINNATOPORA ROBUSTA, Young & Young.

= *Glauconome id.*, Y. & Y., Proc. Nat. Hist. Soc., Glasgow, Vol. III., 1878, pp. 354-355, pl. II., figs. 4, 7, 8, 9, 10.

Zoarium erect, slightly flexuous, bipinnately branching at irregular intervals; pinnæ opposite, or slightly subalternate and bent towards obverse face. *Zoœcia* oval, alternate, about their own length apart. *Keel* on main branches prominent, rounded and tuberculated; tubercles large, irregularly placed, seven or eight to a quarter-of-an-inch; obverse face granular or finely tuberculated "striato granulate."

Locality: Yoredale; Little Urswich, very fine and robust; Gleaston Castle, rare and delicate.

This is not a common form even in the Scotch Carboniferous shales—in the Lancashire shales the best specimens are from Little Urswich—and as is common with many of the fossils from this district, rather ferruginous; specimens from Gleaston can only be recongnised by comparison with examples from other localities. Some of my examples, however, show the strong base and calcified stump to which the growing zoarium was attached.

12. PINNATOPORA ELEGANS ? Young & Young.

Glauconome elegans, Y. & Y., Proc. Nat. Hist. Soc., Glasgow, 1875, p. IV., figs. 27-32.

Glauconome elegans, Vine, Proc. York. Geol. Soc., 1881, p. pl. fig.

There are only two or three fragments present, and these are confined to two localities. I cannot, however, satisfactorily identify the form, but the fragments have the same number of cells between the pinnæ, but the obverse lacks the ornamentation of the common but beautiful Scotch species.

Localities: Yoredale; Little Urswich, North Lancas. Hurst, W. Yorkshire.

13. PINNATOPORA sp.

I possess minute fragments of two or three examples of *Pinnatopora* that I cannot identify with any of the known forms. One specimen closely accords with the description of M'Coy's *P.* (Glauconome) *grandis*,* in possesing three cells between the pinnæ; while another fragment very closely resembles the peculiar ornamentation of *P*, *aspera*† Y. & Y., but the examples are too small for complete identification.

14. PINNATOPORA ? SIMPLEX sp. new, pl. X., fig. 4.

The size of the Zoarium of this beautifully simple *Pinnatopora* is at present unknown. In the example figured it will be seen that the branch is unornamented, and the Zoæcia uncovered by secondary deposits of calcareous matter. The cells are simple, and the general contour of the branch reminds one of a Cheilostomatous, rather than a Cyclostomatous Polyzoon. Between the rows of cells there are

* M'Coy's Carb. Fossils of Ireland.

† Proc. Nat. Hist Soc., Glasgow, 1875, pl. III,, figs. 22-24.

slight undulations which appear to be faintly indicative of a primtave keel, and the only indication of lateral branching appears at the base of the right hand row of cells. Here one cell is stunted, and the one below it is large, having the appearance of an ovicell, but it appears to be rather the originating cell of a branch. I have only met with it in one locality in England, but I believe the same form is present in some of the Scotch shales, and examples are in Mr. J. Young's cabinet.

Locality: Yoredale, Holker Park.

In my British Association Report (1883), on Fossil Polyzoa, I founded the Family Diploporidæ for the reception of all the Carboniferous Species having secondary pores. In the group I placed the so-called Carboniferous *Synocladia ?* as well as other forms. On more mature consideration I find that the association is open to misconception, and in all probability the functions of the "secondary pores" in species of *Septopora* and *Diplopora*, &c., may be different. Under these circumstances it will be far wiser to either found a new family for the reception of the Septopora group and allow Diploporidæ to stand, or to place them in a subsectional division of the Family *Fenestellidæ*, thus:—

Group B.

Genus Synocladia, King (restricted), Permian Fossils.

Genus Septopora, Prout (Redefine from Prout's species).

The latter genus though abundant in American, and in some of the Scotch Carboniferous rocks, has no representative species in the North Lancashire shales, or even, so far as I am acquainted, in any other English locality.

Family Diploporidæ, Vine (restricted).

1883. Fourth Brit. Association Report, Fossil Polyzoa.

1884-5. "Naturalist," Vine, p. 315

Zoarium fenestrated, or partly free and fenestrated. *Zoœcia* arranged biserially in the branch, opening on one side only. Supplementary pores in all the species, placed immediately below the orifice of the cell and separated from it by a thin septum.

Genus Diplopora, Young & Young.
,, Acanthopora, Young & Young.
,, Actinostoma, Young & Young.

It is to this group that Mr. A. W. Waters refers in his paper on Cyclostomatons Bryozoa (Quart. Jour. Geol. Soc., Nov., 1884, p. 675), when speaking of Palæozoic species, and he suggests that probably this peculiar structure may represent the "sub-oral pore and avicularium, and as long as we do not know the signification of the adventitions tubles of *Diastopora obelia*, &c., we may be justified in asking if they may not possibly have had an homologous origin."

15. DIPLOPORA MARGINALIS, Young & Young.

= Glauconome (Diplopora) id., Y. & Y., Proc. Nat. Hist. Soc., Glasgow, 1875, pl. III., figs. 14-21.

= *Glauconome id.*, Vine, Proc. York. Geol. Soc., 1881, p. 333.

Pinnatopora id., Vine, Fourth Brit. Assoc. Rep., 1883; Naturalist, 1884-5.

Zoarium erect, slender, branching at intervals but without pinnæ. *Zoœcia* orifice circular (normal), alternate and marginal which gives a serated outline to the branch—about twenty-four or twenty-six to quarter of inch. On either side of the branch beneath the Zoæcia there is a small secondary pore, which is separated from the larger opening by a delicate septum; if the septum is broken, the Zoæcia (abnormal) is apparently pyriform. *Carina:* (Mesial) a delicate tuberculated keel separates the two rows of marginal Zoæcia. Besides the mesial keel there are others—generally one on either side, *Reverse* finely tuberculated in parallel, longitudinal ridges.

Localities: Yoredale; Gleaston Castle. Hurst, Yorksh. Rather widely distributed in the Lower and Upper Scotch shales.

This is one of the most delicate Polyzoa of the Carboniferous shales, and though rather widely distributed, it is not what may be called a common form in the Upper Shales. There is, however, in some of the more robust examples (often met with in the Yoredale rocks), a slight change in the general aspect of the cell, so much so that at times it is very difficult to identify the Upper Carboniferous with Lower Carboniferous forms. In the Lower Scotch Shales,

especially at Hairmyres, the form is fairly abundant, while in the Upper Scotch Shales examples are far more robust, and these compare more favourably with English specimens found both in North Lancashire and in Northumberland. The Yorkshire examples are somewhat unique.

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16. ACANTHOPORA STELLIPORA, Young & Young.

= *Glauconome stellipora*, Y. & Y., Quart. Jour. Geol. Soc., 1874, p. 682, Vol. XXX., pl. XL., figs. 5-11.

= *Glauconome* (Acanthopora) *stellipora*, Y. & Y., Proc. Nat. Hist. Soc., Glasgow. 1875, pl. IV., figs. 25-26.

= *Glauconome stellipora*, Vine. Proc. Geol. Soc., Yorksh., 1881, p. 333, pl XVI., fig. 1.

This beautiful species is comparatively abundant in the Carboniferous shales generally. In the Lancashire examples the stems are slightly more robust than those that are d rived from the Lower Scotch shales, but the characters are the same. Stem ornamented with a sinuous mesial ridge. *Zoœcia*. orifice circular, over which eight radial denticles converge. "A smaller orifice being placed at one end of the cell (beneath) and separated from the larger aperture by an interval, which never exceeds one-third the diameter of the larger cell."

Localities: Yoredale; Gleaston Castle, Little Urswich, Holker Park, North Lancashire. Hurst, W. Yorkshire.

17. ACANTHOPORA STELLIPORA, Y. & Y. Var. spinosa, Young & Young.

(The same works as referred to for No. 16.)

The branches of the variety have a strong, straight, central keel, not sinuous; this is tuberculated along the central part of the keel. A fragment of the Hurst examples of this variety was figured (Pl. XVI., Vol. VII., Proced. York. Geol. Soc.)

Localities: Yoredale; Gleaston Castle, Little Urswich, Holker Park, North Lancas. Hurst, W. Yorksbire.

18. ACTINOSTOMA FENESTRATUM, Young & Young.

Ibid. Quart. Jour. Geol. Soc., Vol XXX., p. 682, pl. XL., figs. 1-4, pl. XLI., figs. 12-16.

Actinosoma fenestratum, A. W. Waters, Trans. Geol. Soc., Manchester, p.
=*Actinostoma fenestratum*, Vine, Proc. Yorksh. Geol. Soc., 1881.
= *Fenestella nodulosa*, Shrubsole, Quart. Jour. Geol. Soc., May, 1879, p. 280.

The cell characters of this species are similar to the above—denticulate—only that the species is fenestrated. In the earlier paper of Mr. G. W. Shrubsole, he placed this form as a synonym of Phillips' *Fenestella nodulosa*, "as possibly the full development and true type of the species," but in his later paper (op. cit., May, 1881), though dropping the synonym Mr. Shrubsole still regarded *Actinostoma fenestratum* as probably *F. nodulosa* in its perfect condition. I cannot help but regard the species as distinct; but there is much to be said on both sides, and the student would do well to consult both authorities on the subject before describing dogmatically on either side.

Localities: Yoredale; Gleaston Castle, Holker Park, N. Lancas. Hurst, W. Yorksh.

The species is not abundant in the Lancashire shales, but I have met with a few fragments.

19. Spiniferous processes of FENESTELLA and ACTINOSTOMA.

These hook-like appendages of Polyzoa are often met with, and are fairly abundant, in the Lancashire shales. The specimens are both delicate and robust, and when in situ are found on the outer margins of the fenestrated species, as well as on the obverse and reverse of several forms—even including *Polypora* species. On the bases of *F. plebea* they serve as an anchor by which the young zoarium is safely moored to some foreign substance. The Messrs. Young figures several examples in the works already referred to; and in Science Gossip, October and November, 1879, I figured, and also described several forms that are more frequently met with in the shales.

These spiniferous processes, though of a somewhat similar character as *Palæocoryne* of authors, are not included in the descriptions of figures of Messrs. Duncan and Jenkins' original paper on Palæocoryne proper.

Family Polyporidæ.

1883. Fourth Brit. Assoc. Report, Fossil Polyzoa (Mihi).

Zoarium forming large or small fenestrated expansions. *Zoœcia* contiguous in section, with three rows and upwards of cell apertures in the branch, opening on one side only. Branches united by dissepiments or by anastomosis.

Genus Polypora, M'Coy.
,, Phyllopora, King.

Genus Polypora, M'Coy.

Zoarium a delicate or robust reticulated calcareous expansion, branches round, connected by dissepiments. *Zoœcial* apertures circular or pyriform, with from three to five rows of cells in a branch: marginal cells occasionally projecting.

Several species of Carboniferous Polyporæ have been described by authors, but those which have been heretofore found in British rocks, are named either in accord with the descriptions of Prout or of M'Coy. Prout in the Trans. Acad., St. Louis, Vol. I., p. 449, pl. 18, fig. 3, described and figured a species which he named *Polypora tuberculata*, (examples of which are before me), and one of the characters is the peculiar tuberculation of the obverse face. This was pointed out by Mr. John Young, in a paper on Scotch *Polypora* communicated to, and published in the Geological Magazine (1874); and again in a brief note*—accompanying two slides—Mr. Young makes reference to Prout's species.

Many of the differences between the Scotch and the Irish *Polyporæ* were pointed out by Mr. Young when he preferred to re-christen the Scotch form and name it *P. tuberculata*, Prout. The differences between the Scotch and the American examples may now be restated. In the American species of *Polypora tuberculata*, Prout, the fenestration is different, there are from four to five cells on each side of the fenestrule; in Scotch examples I count from five to ten or even more. In Prout's species the dissepiments, on the whole, are likewise different, in the one case short, stunted, and at fairly

* Tran. Geol. Soc., Edinburgh (1874), p. 401.

regular distances, in the other case (Scotch) wide apart and thin. The Zoæcia in the American examples, are seven to a line in length, and in this respect the Scotch examples differ very much, for they are at most either six or five-and-half to the same space, but in the American species there is a tubercle to nearly every cell in the central portion of the branch, seven to a line, while in the Scotch form, there are often only three or at most five to a line. In the American form, the waving striæ between the cells are not a marked feature, whereas even in partially preserved Scotch examples this feature is very striking. I cannot make much of the angularity or rotundity of the reverse aspect of the American and Scotch forms, because these features vary greatly, and above all both Mr. J. M. Nickles, and I believe Mr. Ulrich also, deny the affinity of the Scotch and American *Polypora tuberculata*, and I believe rightly so. Before describing the Yoredale forms I felt that it was incumbent on me to direct attention to these special features, because both the Lancashire and North Yorkshire forms are related to the Scotch but not to the American species. With regard to the tuberculation of the surface, *P. biamarca* Keys, is likewise tuberculate, and even the name M'Coy selected for his species, *verrucosa*, would suggest a similar feature, even though he might not characterise it. The following is a full description of Prout's species diagnosed from American examples:—

POLYPORA TUBERCULATA, Prout, Tran. Acad. Soc., St. Louis.

(See note J. Young, Geol. Mag,, 1874, p. 258).

Zoarium a fan-like expansion. *Branches* (average size) $\frac{1}{32}$ of an inch in breadth, pretty uniform in size, suddenly enlarging before and after bifurcation, dichotomising opposite on two branches, at one, one-and-half, and nearly two lines apart. *Dissepiments* about one third as large as the branches, occasionally expanding at their junction with the branches. *Fenestrules* oblong, subquadrangular, sometimes shortly spatulate or irregular near the bifurcations. *Zoœcia* small round, eleven to twelve cells to three millemetres, penistomes thin, circular, and very slightly raised, tubercles small, one to every cell, on the central part of the branches, occasionally absent from the marginal cell, but not invariably so; some of the tubercles overhang the orifice of the cell like the ovicell in the

Cheilostomata;* Zoœcia five, tubercles five or even more to each fenestrule; intervals between the cells, and reverse of branches also delicately granular or pimpled.

Mr. Young (op. cit. Geol. Mag.) says, after quoting Prout's description—" To what Prout states one or two additions require to be made. The thin lips of the pores in well preserved specimens are not circular, but sinks down on the lower edge of the aperture, which thus has a pyriform crater shape. In addition to the ridges mentioned by Prout *(the ridges do not exist in American examples before me)*, the intervening surface is covered with very fine short wrinkles, which are sinuous and sometimes interrupted, so as to give a tubercular aspect." If we add to this that eight cells occupy the space of three millemeters, all identity is destroyed between the Scotch and American Carboniferous *Polypora tuberculata*, and I am compelled, therefore, to accept M'Coy's name for the Yoredale, rather than that given to the Scotch forms.

20 POLYPORA VERRUCOSA ? M'Coy. (Provisional). Pl. X., fig. 5.
= *Polypora tuberculata*, Vine, Proc. Geol. Soc., Yorks., Vol. VII., 1881, pp. 336-337, pl. XVI., fig. 5.
= *Polypora tuberculata* (pars) Vine, Brit. Assoc. Rep., Foss. Polyzoa.

Under present circumstances it will be best to place the Yoredale species here, and I shall not attempt to describe the fragments otherwise than by brief notes. Though rather abundant in some localities I have not a specimen larger than about half-inch square, so that I am not able to give any dimensions as to size. The Zoarium is fenestrated irregularly, similar to Scotch forms. Zoœcial apertures circular, with intervening spaces between filled in with wavy striæ; marginal cells only slightly indenting the edge but not so prominent as in Scotch forms. *Tubercles* present, but only occasionally conspicuous. In one well preserved fragment, plate X., fig. 5, which appears to me to belong to this species, there is, however, a prominent (though delicate) undulating keel running down the central part of the branch, upon which the tubercles are placed, one to every two cell, but by no means so robust as the Scotch examples.

* There is no comparison between the two.

Localities: Yoredale; Holker Park, common; Hurst, Yorkshire.

21. POLYPORA (?) sp., provisional.

There are present in the North Lancashire rocks fragments of what may ultimately prove to be another species of *Polypora*, but my example does not warrant their individualisation. In the Derbyshire and North Yorkshire strata I regard the *Polypora laxa*, Phillips', as distinct from either of the above.

Phyllopora is not, so far as I am acquainted with Palæozoic Polyzoa, a Carboniferous Genus. Species of the Genus are found in the Silurian Rocks, both of this country and America; there are examples of the Genus in the Permian Rocks also.

Family THAMNISCIDA.

1883. Fourth Brit. Assoc. Report, Fossil Polyzoa.

Zoarium forming free dichotomising branches, or pinnated fronds. *Zoœcia* on one side only, with from three to five (or more ?) rows of cell openings in the branch, occasionally having a smaller opening above or below the peristome of the cell (base of a spine ?).

Genus THAMNISCUS, King.

Genus ACANTHOCLADIA, King ? = *Ichthyorachis*, M'Coy.

In my paper on West Yorkshire and Derbyshire Polyzoa (Proc. Yorks. Geol. Soc., 1883), I describe a new variety of *Thamniscus dubuis* ? King, which I characterise as var *Carbonarius* (pp. cit. p. 170), and Messrs. Young, of Glasgow, have also described a Scotch form which they named *T. Rankinei*, which is doubtfully present in the North Lancashire material.

Genus THAMNISCUS, King (Permian Fossils).

Restricted by Mr. G. W. Shrubsole, Quart. Jour. Geol. Soc., Aug., 1882.

Zoarium mulitiform; branches free, round, frequently and regularly bifurcating, more or less in one plane. *Zoœcia* on one side, cells immersed, apertures round, arranged in oblique lines. Reverse foraminated.

22. THAMNISCUS DUBIUS, King (Permian Fossils) *Var. a.* carbonarius, Vine, Proc. York. Geol. Soc., 1883, p. 171.

I place some fragments from Holker Park here, but I am rather doubtful of the association.

23. THAMNISCUS GRACILIS new sp. pl. X., figs. 6-6*a*.

Size of Zoarium unknown; branches flattened, dividing irregularly, *Zoœcia* on one side only, and with from three to four rows of cells in the branch, cells immersed, apertures circular, peristome slightly prominent, delicately tuberculated, with from eight to ten tubercles, occasionally one or two rather larger than the others in the circlet, about six cell apertures in the space of a line, intervening spaces between the cells likewise tuberculated. Reverse concave, very rarely rounded, striato-granulate, with from four, six, eight, or ten rows, according to the size of the examples.

Localities: Yoredale, Gleaston Castle.

This beautifully graceful polyzoon I have not previously met with in any of my British shales. It is fairly abundant in the North Lancashire shales. There is in the American rocks a very peculiar species which Mr. E. O. Ulrich has provisionally named—though not described—*Stenopea gracilis* (MS), but the distinctive features of the American forms are well marked, and could not, except in the delicacy of the branching, be confounded with the present species. It appears to me, however, that the American form may be fittingly placed among the Thamniscidæ.

24. THAMNISCUS RANKINEI (?) Young & Young.

I place here a few fragments of a species of *Thamniscus*, doubtfully akin to the above well-marked species.

Locality: Yoredale, Holker Park.

Sub-Order, CRYPTOSTOMATA, Vine.

1883. Fourth British Assoc. Report, Fossil Polyzoa.
1884. "Naturalist," October, p. 65.

Zoœcia tubular, sub-tubular, in section (occassionally) slightly angular. *Orifice* of cell surrounded by vestibule, concealed.

Family RHABDOMESONTIDÆ, Vine.

1883. British Association Fourth Rep. Foss. Polyzoa.
1884. Rhabdomesontidæ, Ulrich. Jour. Cincin. Soc. Nat. Hist., April, 1884.

This family was founded for the purpose of receiving the two species of *Millepore* of Phillips, which were more fully described by

the Messrs. Young, of Glasgow, under the name of *Rhabdomeson*, Young & Young. Since the publication of the Brit. Assoc. Report, Mr. E. O. Ulrich accepted the family, and placed in it the genus *Rhombopora*, Meek. Although I am quite willing to admit that externally, certain species of Rhombopora are almost indistinguishable from *Rhabdomeson gracile*, still Mr. Ulrich says that there is an absence of the central rod in the American species. Now this feature in *R. gracile* is most characteristic, and in the Tearne Limestone, Scotland, where the form is abundant, the rod in vertical sections is markedly conspicuous. Yet notwithstanding this one character—the central rod—I am inclined to admit also that there is much force in the further remarks of Mr. Ulrich when he says, "While sections of the two genera (Rhabdomeson and Rhombopora) are . . . . readily distinguished, it is, on the other hand, not nearly so easy to separate them by their superficial characters. Indeed, examples of *Rhombopora persimiles*, Ulrich, from the Kaskaskia group of Kentucky and Illinois, resembles specimens of *Rhabdomeson gracile* so closely in growth, Zoœcial apertures, and distribution of spines, that it requires no little amount of patience to distinguish them successfully."* Under these circumstances, and to avoid the introduction of another family name it will be best to divide the group into two sections, especially so when we have some of the American Rhombopora, or very near allies, in British Carboniferous Rocks.

Section A. *Zoœcia* attached to a central rod.

Genus, RHABDOMESON Young & Young.

Section B. *Zoœcia* radiating in all directions from an imaginary axis.

Genus, RHOMBOPORA, Meek.

Section A.

Genus RHABDOMESON, Young & Young.

1874. Annals and Mag. Nat. Hist., May, p. 337.
1875. Annals and Mag. Nat. Hist., May, p. 334.

Zoarium slender, rod-like. Axis a thin calcareous tube to which the *Zoœcia* are attached and from which they radiate in all directions.

* E. O. Ulrich, op. cit. p. 25.

25. RHABDOMESON GRACILE (Phill. sp. Palæozoic Foss.) pl. X., fig. 11.

= *Millepora graciles*, Phill.

= *Ceriopora gracilis*, Morris's Catalogue of Brit. Foss.

Rhabdomeson gracile, Young & Young, "Annals," May, 1884, p. 337, pl. XVI., figs. 1 to 5.

Rhabdomeson gracile Vine, Proc. Yorks. Geol. Soc., op. cit.

Zoarium rod-like, slender, cylindrical and branching. *Branches* coming off at right angles to the stem and never less than an inch apart, *Stem* consisting of a hollow axis formed by a thin calcareous tube, and of a series of cells ranged round the axis. *Zoœcial apertures* oval, surrounded by tuberculated ridges, which bear two blunt spines, one on the upper and the other on the lower angles of each aperture. *Zoœcia* conical, consisting of two parts, the vestibule and the cell proper.

Localities: Yoredale; Holker Park, Gleaston Castle, Little Urswick. Hurst, Yorks. Northumberland, and very generally distributed in British Carboniferous Rocks; Devonian (Phill).

26. RHABDOMESON RHOMBIFERUM, Phillips, sp.

= Ceriopora rhombifera, Phill.

Rhabdomeson rhombiferum, Y. & Y., Ann. Mag. Nat. Hist., May, 1875, pp. 333, 334, pl. IX.

Zoarium slender, cyclindrical free. Branches of nearly equal diameter, given off at intervals at right angles to the stem. *Zoœcia* opening all round the stem, orifice of zoœcial chamber at the bottom of depressed area (vestibule). *Vestibule* rhomboidal or hexagonal in outline, bounded by narrow tuberculated ridges, the tubercles on which are larger at the angles of junction; average number of tubercles round each area, sixteen; areas of zoœcial chambers more numerous on one side than on the other. "Here and there depressed pits with quadrangular boundaries intervene between adjacent cell areas; but they are cæcal, and do not show in tranverse sections." *Axis* slender, slightly flexous.

Localites: Yoredale; Gleaston Castle, Holker Park, North Lancas., Hurst, W. Yorks.

Section B. Zoæcia radiating in all directions from an imaginary axis.

Genus, RHOMBOPORA, Meek.

1871. Palæontology, Eastern Nebraska.
1884. Ulrich, Jour. Cincin. Soc. Nat. Hist., April.
1885. Vine, Proceedings Yorks. Geol. Soc., Vol. VIII., p. 105.

Type of Genus, *R. lepidodendroidea,* Meek, Up. Coal Measures, Nebraska and Wyoming.

Zoarium ramose, branches slender. *Zoæcia* tubular, radiating in all directions from an imaginary axis; walls abruptly thickened in the "matured" region, where the diameter of the visceral cavity is also more or less constricted. Zoœcial apertures, circular or oval, placed at the bottom of more or less obviously impressed sloping rhomboidal to hexagonal "vestibules." Ridges separating vestibules, spiniferous; spines, hollow, often of two kinds, large and small, the latter most numerous, and surrounding the apertures in a single or double series, while the larger spines are usually developed only at the uppermost extremity of the cell. (Diaphragms [tabula, Nicholson] generally absent, always few). Zoœcial apertures frequently closed by centrally perforated operculæ. Ulrich (op. cit., p. 26).

27. RHOMBOPORA PERSIMILIS, Ulrich.

Jour. Cincin. Soc. Nat. Hist, 1884, p. 30, pl. I., figs 7*a* to 7*d*.
Ibid, Vine, Proceed. Yorks. Geol. Soc., 1884, p. 106.

The North Lancashire examples of this species are very similar to the Yorkshire. There is, however, a slight calcareous thickening of the delicate spines in the margins of the vestibular apertures. Apparently this is caused by a secondary (chemical?) deposit after (?) the extinction of life in the Zoarium. Other spiniferous, or tubercular species, are likewise affected by similar conditions, but only in certain localities.

Localities: Yoredale; Gleaston Castle, N. Lancas., Hurst, W. Yorkshire.

28. RHOMBOPORA SIMILIS? Phillips' species.

= ? *Ceriopora similis*, Phill. Palæozoic Fossils.

In the Upper Shales of Scotland, and also in the Yoredale rocks of North Lancashire and North Yorkshire, there are examples of a species, that, for the present, I refer to Phillips' *Ceriopora similes.* The shapes of the vestibules may be described as passing from

round to slightly hexagonal, and tuberculated on the ridges. The inner portion of the vestibule slope away from the ridges towards a small circular or eliptical cell orifice. A similar feature is noticible in that of *Rhombopora elegantula*, Ulrich, Jour. Cincin. Soc. Nat. Hist., April, 1884, p. 33), but the mode of branching in the British species is more like that of *Anisotrypa symmetrica*, Ul. (Op. cit., Dec., 1883, p. 176, pl. XIII., fig. 5). The branches of the Hurst and Lancashire specimens are not quite so large as the American.

Horizon and Localities: Yoredale; North Lancas., Hurst, W. Yorks.

29. RHOMBOPORA VINCULARIFORMIS, n. sp. Pl. X., fig. 10.

Size of Zoarium and mode of branching unknown. Stem very delicate, or in some specimens rather robust. Zoœcial apertures slightly prominent; vestibule eliptical; cells arranged in lines, with their posterior ends elongated. On both sides of all the linear series of cells there are undulating rows of tubercles.

Locality: Yoredale; Gleaston Castle.

This delicate little form may have been previously noticed by authors even if not fully described. M'Coy's *Vincularia megastome* has a similar arrangement of cells, but I believe that he has not described the ornamentation in his species. Mr. John Young, however, has examples of a similar form to the North Lancashire species described above, which he has named (provisionally?) *V. megastoma*, M'Coy, the locality of which he gives as Brockley, near Lesmahagow.

30. RHOMBOPORA sp.

There are present in the North Lancashire, Northumberland, and also in the Hurst Shales, several fragments of species of *Rhombopora*, more allied to American than to any British forms. These will merit further study, and as there are difficulties to be overcome when we have to rely on external features only, I shall not be blamed, I hope, if for the present I withhold special details. I felt that it was necessary to make reference to these, otherwise, students of Carboniferous Polyzoa may detect undescribed fragments and be puzzled respecting them.

Family CYSTODICTYONIDÆ, Ulrich.

Jour. Cincin. Soc. Nat. Hist., April, 1884, p. 34.

Fam. *Arcanoporidæ*, Vine, "Naturalist," Oct., 1884, p. 65, and Fourth Brit. Assoc. Rep. Foss. Polyzoa, 1883.

For reasons given in the above I have already suppressed the Family name. As the name was founded upon, and applied to, British examples alone, the combination of Genera was not, perhaps, the happiest. The interstitial spaces between the cells, however, being occupied by "versicular tissue," both the Family and Generic terms are by far the most natural.

Genus CYSTODICTYÆ, Ulrich.

(Op. cit., above, p. 36, Hp., 1884.)

= *Arcanopora*, Vine; Fourth B. A. Rep. Foss. Polyzoa.

31. CYSTODICTYA PARALLELA, Phill.

= *Flustra? parallela*, Phill., Geol. Yorksh.

= *Sulcoretepora* id., M'Coy, and authors generally.

Cystodictya id., Vine, "Naturalist," October, 1884, p. 65, Sept., 1885, p. 317.

This form is well distributed in British rocks, and Mr. Ulrich says that he has identified the form in the Keokuk group (Lower Carboniferous) of Kentucky, and he says "the American specimens, though a little longer, agree closely in other respects with authentic British examples.

Localities, &c.: Yoredale; Gleaston Castle, Holker Park, N. Lancas., Hurst, W. Yorks.

32. CYSTODICTYA RARICOSTA, M'Coy

= Vincularia raricosta, M'Coy.

There are present in the North Lancashire shales a few fragments that are very similar to the Scotch examples of this species, but at present, I am unable to say whether *C. raricosta* can be sustained. The *Cystodictya* are a very variable group, and at some future time it may be well to direct special attention to American and British forms.

Localities, &c.: Yoredale; Holker Park, North Lancashire.

Family *Hyphasmoporidæ* (?) Provisional.

33. HYPHASMOPORA, Buskii, Eth., Jun.

Ann. Mag. Nat. Hist., Ser. 4, Vol. XV., pp. 43-45, pl. IV., figs. 1-S.

Zoarium dendroid, composed of small cylindrical stems, often bifurcating, *Zoœcia* arranged in linear longitudinal series, more or less separated from one another by a cancellated network or reticulation; cells on the obverse side compressed, and occasionally separated from contiguous cells by dividing ridges; lateral cells larger and bordering on the reverse of the stem, which is always cancellated and destitute of Zoœcia. *Vestibules* large pyriform, within the depressed or slanting area of which the orifices of the conical cells are seen.

Horizon and Localities: Yoredale; Gleaston Castle, Holker Park, North Lancas. Hurst, North Yorks.; Northumberland. Upper and Lower Shales but very rare.

This species has a very wide distribution in the Carboniferous rocks of Great Britain. The characters, however, though well-marked, are likely to be confounded with another species which I have already drawn attention to in a previous paper,* under the name of *Streblotrypa Nicklisi*, MS., Ulrich. My object in naming my Yorkshire specimen after a MS. name, was to draw closer attention to Carboniferous British and American Polyzoa than have heretofore been done; but American Palæontologists seem to misunderstand, or misconstrue, my motive. This I cannot help or avoid, and this plain matter-of-fact statement ought to be sufficient to prevent misconception for the future. It is necessary in dealing with fossils of the same or similar horizons that comparisons should be made, and distinctions drawn whenever possible, and jealousy on either side ought to be less regarded than the truth.

34. STREBLOTRYPA NICKLISII (Ulrich, MS.)

S. Nicklisii, Vine, Proc. Yorks. Geol. Soc., Vol. VIII., 1885, pp. 107-8, pl. XXI., figs. 4-5.

This particular species is rather more abundant, in association with another form, in the Carboniferous shales than I previously contemplated. In the Lancashire Yoredale shales the species is well represented, and Mr. John Young showed me lately several examples derived from Scotch local shales. I do not see, however, why the species should be separated from a family association with

* Proceed. Yorks. Geo. Soc., 1883-4, p. 107.

Hyphasmopora, and I suggest, as a provisional placement, a family name that appears to me to be appropriate. It may be that further researches among the Sub-Carboniferous Polyzoa on the other side of the Atlantic may institute links by which the species may fall in naturally with some other of the Carboniferous groups. At present, however, I know of no British forms that could be satisfactorily used for that purpose.

Horizon and Locality: Yoredale; Gleaston Castle, Holker Park, North Lancas. Hurst, North Yorkshire.

35. STREBLOTRYPA (?) var. MINUTA, var. new, pl. X., figs. 7, 8, 9.

The *Zoarium* of this beautiful minute form is smaller than *S. Nicklisii*, but the cell arrangement is the same, only that in some of the examples of the variety the cells are more compressed, and the young cells of the branches are rounded at the distal extremity (pl. X., fig. 7*a*), and rather differently shaped. In the type species these rounded cells, at least in my specimens, do not appear. In this minute variety too, the area beneath the cell orifice (pl. X., fig. 8*a*), is well marked. In all probability when the species becomes more fully known there will be no necessity for the distinctions between type species and variety, but I believe that it will be better for the Palæontologist to direct attention to the varietal characters.

Localities, &c.: Yoredale; Gleaston Castle, Holker Park.

Associated with the Polyzoa of the North Lancashire rocks, there are a number of fragments of different species that I cannot help but regard as *Ovicells*. These are so varied in their characters that for the present I can only make reference to them, in the hope that at some future time I may be able to furnish a paper on these reproductive chambers especially. There are also a few remaining examples of species closely related to American varieties, these I may also be able to attack, but at present time I should have to rely upon MS. names which have been supplied to me with American undescribed examples.

Description of Plate X.

With the exception of 8*a*, the rest of the figures are drawn with camera lucida and magnified about 30 diameters.

1. Pinnatopora ornata, new sp.

2. Pinnatopora ornata, reverse showing the linear arrangement of granulations.
3. ,, ,, single cell enlarged to show character.
4. Pinnatopora simplex, n. sp.
5. Polypora verrucosa (?) provisional.
6. Thamniscus gracilis, n. sp., 6*a* showing reverse and portion of margin.
7. Streblotrypa (?) var. *minuta*, new var.
8. ,, other examples 8*a* and 9.
10. Rhombopora ? vinculariformis, new sp.
11. Rhabdomeson gracile, Phill.

NOTE ON CHLAMYDOSELACHUS ANGUINEUS, GARMAN. BY JAMES W. DAVIS, F.G.S.

It is proposed to draw attention to an existing species of Selachian obtained by Prof. H. A. Ward along with other natural history specimens in Japan. It was afterwards purchased for the Museum of Comparative Zoölogy, at Harvard College, and in January, 1884, Mr. S. Garman, of Agassiz Museum, Cambridge, U.S.A., gave a preliminary description of the fish in the Bulletin of the Essex Institute, Vol. XVI., in which he recognised it as belonging to a new family, and confered upon it the generic and specific names at the head of this note. A further contribution, entitled, "A Peculiar Selachian," appeared in "Science," a weekly American journal, on Feby. 1st, 1884 (Vol. III., p. 116). In this it is stated that "the body is long and slender, five feet in total length, and less than four inches in greatest diameter; it becomes compressed and thin towards the tail. The head is broad, slightly convex on the crown. The mouth is anterior and very wide. As in other sharks the teeth are arranged in rows across the jaws; they are all alike. Each tooth has three slender, curved, inward-directed cusps, and a broad base, which extends back in a pair of points under the next tooth, thereby securing firmness and preventing reversion. There are six gill openings: the anterior one very wide. Unlike other

Selachians, in this, the frill or flap, covering the first opening is free across the isthmus, as in fishes, and hangs down about half-an-inch. The nostrils are nearly vertical, with a fold dividing each orifice into two parts. The eyes are moderately large, on the side of the head, midway over the length of the mouth: there is no trace of nictitating membrane. The pectoral fins are of moderate size, and are separated by a distance of two feet from the ventrals. The ventral, anal, and candal are large. Above the anal fin there is a small dorsal. At their margins the fins are very thin, and their extremities are produced in a sort of filament. The structure of the jaws and gill arches is such as to admit of swallowing a large object, at the same time the excessive sharpness of the teeth, and the small size of intestine, indicate that the prey is comparatively soft. The vertebræ and other cartilages are flexible, as those of the basking sharks, Selache and Somniosus. A certain embryonic appearance in the specimen instigated a search among the fossils for allied species. Most resemblance was found in the teeth of Cladodus of the Devonian: but the cusps were erect instead of reclining, and the enamel was grooved instead of smooth. One is impressed by a study of this specimen with the idea that, away back in times when selachia and fishes were more alike, he would have a better chance to trace the affinities. I am inclined to consider this the type of a new order, to which the name Selachophichthyoidi might be given, and which stands nearer the true fishes than do the sharks proper."

After the publication by Mr. Garman of the above, somewhat superficial description, a considerable amount of correspondence took place in the pages of "Science," and diverse opinions were expressed as to the relationship of the genus to extinct forms. Prof. E. D. Cope, on March 7th, considers that the teeth figured by Mr. Garman "shows the animal to be a species of the genus Didymodus (=Diplodus, Agass) which has hitherto been supposed to to be confined to the Carboniferous and Permian periods," and in the "American Naturalist" of the following month, he confirms his opinion to a greater length, and states that the species should be called *Didymodus anguineus*.

Prof. Theo. Gill, expresses an opinion that Chlamydoselachus

appears as a new element in Selachology, and becomes the representative of a hitherto unknown type, and throws light on the ancestry of some of the extinct forms of the class. He suggests the name Pternodonta as preferable to the one given by Mr. Garman, and considers the fish to be the type of at least a sub-order. Prof. Gill is disposed to consider Chlamydoselachus to stand "nearer the true fishes than do the sharks proper, not because it appears to be in the line of descent between the two, but because it is nearer the primitive line from which both types have diverged." Thus far he agrees with Mr. Garman, but he dissents emphatically from him in regarding the recent acquisition as a Cladodont shark, basing his objection mainly on the description by Dr. Traquair of *Ctenacanthus costellatus* (Geological Magazine, dec. 3, Vol. I., pp. 3-8, pl. 2). He agrees with Prof. Cope that Chlamydoselachus did have a representative in the Carboniferous genus Diplodus, Agass (or Didymodus, Cope), although he does not think that the two can be congeneric.

Professor Gill classifies the genera Hybodus, Cladodus, Ctenacanthus, &c., selachians without developed vertebræ, but with a persistent notochord, in the Lipospondyli; and the genera Diplodus and Chlamydoselachus, vertebral condition unknown, and with teeth having fixed bases, he places in Pternodonta or Selachophichthyoidi, and ventures an opinion thot the Hybodontidæ may not have been Squali at all, but more nearly related to the Holocephali, and that both may have diverged from some primitive form theoretically not unlike Ctenacanthus. A month later, having seen Professor Cope's article in the American Naturalist, Professor Gill entirely changes his opinion, and in a communication to Science (Vol. III., No. 62, p. 429) he says: "I am convinced, not only that Didymodus has no generic or even family relations with Chlamydoselachus, but that it represents even a different order." Then follows a history of Diplodus which in consonance with the opinion of the late Sir Philip Egerton he places in the genus Pleuracanthus and concludes "as to Chlamydoselachus the anatomy will probably reveal a structure most like that of the Opistharthri (Notidanidæ) but of a somewhat more primitive type."

This communication from Professor Gill was followed by another from the pen of Professor Cope, in Science, of May 30th, 1884, in which he acknowledges that he stands corrected by Professor Gill's superior knowledge of the literature of the subject; the genus Diplodus he regards as a synonym of Pleuracanthus, but as Pleuracanthus has a nucal spine along with tricuspidate teeth and the specimens which he regarded as the type of the genus Didymodus have not hitherto been proved to have spines, though the spines of Pleuracanthus have been found separately in the same beds, Professor Cope thinks that the identity of Didymodus with Pleuracanthus may now be questioned. He also states that there is no generic difference to be detected between the teeth which are typical of Diplodus, Agassiz, Trinacodus, St. John and Worthen, and the recent Chlamydoselachus: there are differences but not of generic value. But, as Diplodus must be regarded as a synonyme of Pleuracanthus, it follows that Chlamydoselachus, Garm., is distinct on account of the different structure of the dorsal fin, which is single and elongate in Pleuracanthus: the presence of the nucal spine in Pleuracanthus is also, probably a character of distinction. Professor Cope further suspects that the skulls of Didymodus he has described represent a different genus from Pleuracanthus proper, and that so far as we know Chlamydoselachus, it will not differ from Didymodus, though a study of the anatomy of the former may reveal differences between that genus and Didymodus. These views were reiterated by Professor Cope in his paper on the structure of the skull in the Elasmobranch genus Didymodus, published in July in the Proceedings of the American Philosophical Society of Philadelphia.

The discussion on the palæontological affinities of this remarkable fish appear to have reached a climax at the meeting of the American Association for the Advancement of Science, at Philadelphia, in September, 1884, when Mr. S. Garman read a paper on his discovery of Chlamydoselachus, and after discussing its relationship, Professor Cope abandoned his position concerning the affinities of Didymodus and the recent fish, and agreed that judging from the teeth alone, its nearest known allies were the Cladodonts of the Carboniferous and Devonian rocks, and Professor Gill writing

to Science on December 12th, states that "the differences between himself and Mr. Garman are fictitious rather than real, or better, perhaps, they are chiefly differences of expression, but he still dissents from the opinion that the Cladodontidæ are related to the Chlamydoselachidæ rather than the Hybodontidæ."

During July of the present year, Mr. Garman has published a detailed description of "Chlamydoselachus anguineus—a living species of Cladodont Shark" in the Bulletin of the Museum of Comparative Zoölogy at Haward College, Vol. XII., No. 1, pp. 1-35, Plates I-XX., and the great interest attaching to this recent example of a shark which bears, at any rate, a close resemblance in the form of its teeth to those of fishes which have been until now considered as long ago extinct, and whose only remains capabable of identification, consists in the teeth, must be my apology for extracting the following resumè from the valuable memoir of Mr. Garman.

The total length of the specimen is 59·5 inches. From the snout to the angle of the mouth 4·5, to the end of gill-covers 7·0, to base of pectorals 8·5, to base of ventals 32·0, to base of anal 39·75, to base of dorsal 42·25, and to base of candal 48·5 inches. The width of the head across the eyes is 3·5, the diameter of the body one-fifteenth of its length. An elongated body, a long subtriangular and flattened head, an anterior mouth, a most extensive gape, jaws bristling with sharp subconical hooked teeth, and a sinister look about the eyes, give it a remote resemblance to certain ophidia: and the narrow isthmus between the jaws crossed by the free mantle or flap of the first gill-cover is strongly suggestive of certain fishes. The resemblance to sharks and fishes is only remote: the shagreen, the fins, the teeth, the gill openings, the cartilaginous skeleton, etc., shew the animal at once to be a Selachian, one of the sharks.

The single dorsal and the large ventrals, anal, and candal, have the appearance of being bunched together: they are placed so far back as to leave a space almost two feet of the length entirely unrelieved by fins, which contributes considerably towards an eel-like appearance.

The skull is short, and jaws and suspensorium (hyomandibular) being very long and loosely articulated, the hinder portion of the

head spreads easily till its width equals its length. and the outline from above resembles an equilateral triangle, or, better, an arrowhead with barbs. The gape is wide. Both mouth and throat are lined with shagreen. On the inner edges of the gill arches the scales are larger. At the angle of the jaws there are neither labial folds nor labial cartilages. The eye is moderately large; it is on the side of the head, over the middle of the length of the jaws, and from the sharp, rather prominent brow, has a savage look There is no nictitating membrane, but around the pupil the skin covering the eyeball is rough with small scales. The snout extends but little in advance of the mouth. The nostrils are lateral: placed about half-way between the eyes and the snout similar in structure to Notidanidæ. The gill-openings are large, oblique; arches slender. The opercular flap or first gill cover is broad and free around the neck except for a short space behind the occiput.

Collett's
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An open canal, the lateral line, extends on each side from the back of the skull to the end of the tail; other open canals, branches of the same system, ramify in several directions over the head. The pectoral are separated from the ventral fins by a distance of twenty-two inches: at this part of the body the height is four inches, the width three inches. A prominent double or grooved keel along the median abdominal line adds considerably to the depth, in the centre of the body it projects three-quarters of an inch. From their position, shape, and extent, it is considered that the folds will furnish support to one of the theories of the origin of paired fins. The muscle of the inside of the keel corresponds to the *rectus abdominis* of other vertebrates.

None of the fins are rigid but on the contrary very soft, and like the body itself extremely flexible. They are covered with shagreen except near the outer edges, which are thin and membranous. The dorsal is single, comparatively small, five-and-a-half inches in length, opposite to the anal. Its anterior origin is indicated by a peculiar armature. The pectoral, ventral, anal, and candal fins are large. The pectorals are moderately long, 5·75 inches, both margins are curved meeting in a blunt angle at the end of the fin. The ventrals are placed some distance behind the middle of the total

length. They are about an inch longer than the pectorals, the reverse of what is usual amongst sharks: each is broadly rounded, twice as long as wide, and ends in an acute point behind the neck. The anal fin is nearly eight inches in length and three in breadth, the lower margin is curved and the posterior extremity forms an acute angle. The tail is without a pit at its root, and the fin is not divided into lobes by a notch at its lower border. The upper portion of the fin is not more than three-eighths of an inch in height: the lower portion is little short of three-and-a-half-inches in its greatest depth, and with its filamentary extremity is not far from twelve inches in length.

The teeth are arranged in fifty-one rows with six in each row. There are thirteen in each ramus of the upper jaw and twelve on each side of the lower jaw, and in the latter there is also one median row on the symphysis. All the teeth are small, the largest is barely a quarter of an inch across the tips of the cusps, and the smallest is less than one-sixteenth: they consist of three long, slender, very sharp, subconical cusps, separated by a pair of rudimentary denticles or buttons, on a broad backward-extended base. The anterior teeth are largest and they decrease in size backwards. Behind the teeth proper, on each jaw there is a patch of scales similar to those on the lips at the angle of the mouth. Anteriorly the cusps are bent over backwards towards the base, those behind are nearly or quite erect, the points are bent slightly upwards or forwards. On each side the median cone and on the inside of the lateral ones a slight ridge runs from the base to the apex. A small button is situated between the central and each lateral cusp, and behind these a ridge extends backwards over the base which ends in a pair of prongs extending beneath the base of the next tooth in the row to the extent of one-third of its length. In the posterior rows of teeth, their bases are somewhat distorted, the median cusp is considerably longer than the lateral ones. The buttons disappear in plications. "For a description of a tooth of the twelfth or thirteenth row that of *Cladodus mirabilis*, Agass, is not far out of the way; in fact it agrees so well hat, if consideration was limited to that particular tooth, one could. thave little hesitation in naming the new species *Cladodus auguineus*

Possibly the bases of *C. mirabilis* might not accord so well. *Pternodus springeri* and *P. armatus* (*Pristicladodus springeri* and *var. armatus*, St. J. and W.) present forms of bases which are intermediate between those of Chlamydoselachus and Cladodus, as shewn in the numerous specimens figured by St. John and Worthen."

The scales on the entire body are small; and irregular in size and shape. On the sides and abdominal surfaces they are depressed polygonal plates surmounted by one, two, or three sharp prominences, the median of which is the stronger, in places becoming a keel. On the tail this keel is produced beyond the base as a sharp spine with thin longitudinal ridges. About the mouth and in particular around its angles, the spines are larger, more conical and more erect; more like teeth. In the mouth, just behind the last row of teeth, there are spines, which are more slender, and which have broader bases; these resemble the teeth of certain fossil species which have single cusps. They are hardly one-fourth as large as the teeth immediately it front of them. Where worn the scales are smoother. The upper edge of the tail and its posterior border, to the lateral line, is armed with a sharp edge of scales. The edge is formed of two rows, one from each side, of broad thin, subquadrangular scales which have met on the median line and become so closely applied as to appear a single ridge. Near the base the plates are striated: the distal halves are smooth. Similar scales guard the front or upper edge of the dorsal fin: and on each side of the lateral line, elongate scales with truncated ends protect the canal.

The internal organization of Chlamydoselachus offers quite as many peculiar features as its external. The head is comparatively small for the length of the body; the jaws are long compared with the head, and are suspended considerably further back than in any existing shark, and present a remote resemblance to the serpents. In the Notidanidæ the articulations of the jaws are as far back as in any of the sharks, but even in that family the jaws pass a little behind the skull, whilst in this genus they extend nearly as far behind the occipital as in front of it. Mr. Garman remarks that "the skull of the frilled sharks is suggestive of immaturity: the thin walls, soft cartilage, and large pores and foramina with thin

edges round them, seem to be those of a young, rather than an adult specimen. Compared with an Heptabranchias it agrees better with an emybro than an adult." The jaws are five inches in length, cartilaginous, somewhat thick and twisted, and posteriorly are attached to a suspensorium connecting them with the skull, which is three inches in length. The posterior surface of the suspensorium bears nine branchial rays. The brain is small. In its ontlines and proportions it shows great similarity to that of the Notidanidæ, but it is comparatively much smaller than in the higher sharks such as Carcharias or Zygæna. The olfactory and optic lobes and nerves are large as compared with the whole of the brain. In the branchial cartilages the basi-branchials indicate a low rank in the developement of the fish.

The vertebræ, for a short distance only behind the head, can be distinguished by constrictions, and are slightly calcified; beyond, in the middle of the body the vertebræ can only be distinguished by the apophyses. The notchchord is persistent. In the neural canal and between the interneurals the segments are tolerably distinct. Over the abdominal cavity the hæmal processes bear short flexible unsegmented ribs. Above the anal fin the hæmapophyses begin to take a downward blade-like extension, and are supplemented by small pieces of cartilage which further back become the radials of the caudal. The column ends abruptly; the terminal segment resembles a slice taken from the front of a following vertebræ. The pectoral and ventral fins are supported by a well-defined cartilaginous framework, attached to which are a series of three radials, the inner row elongate, the outer one short and small. A series of cartilages of irregular form support the dorsal and anal fins, they are disconnected from, or only connected by a membrane with, the vertebral apophyses. The cartilages of the dorsal fin are large as compared with the size of the fin itself, and appear to indicate that the fin in ancestral forms was much larger, and has become atrophied in the present specimen.

The heart presents a somewhat peculiar form differing in details from the ordinary sharks. It has a small sub-quadangular ventricle, a large auricle, and a long bulbus arteriosus containing six rows of

valves. Behind the auricle and above and behind the ventricle, lies the sinus which has a capacity that nearly equals the bulk of the ventricle. In sharks the bulbus arteriosus is short and the rows of valves number from two to five.

The internal organs were for the most part torn away and lost, but sufficient of the intestine remains to show that it possessed a spiral valve and a cæcal pouch behind the valve.

The genus Chlamydoselachus differs so materially not only in its dentition, but also in its general form and structure from that of Pleuracanthus, Ag. (Xenacanthus, Beyrick), that there can be little hesitation in deciding that no near relationship exists between the two. Pleuracanthus had a broad, depressed head, large in proportion to the size of the body, rather short but very wide gape, the anterior portion of the jaws forming the extremity of the head. The gill arches were four or five in number. The well-known spine was attached immediately behind the occupital region, and was one-fourth or one-fifth the entire length of the fish. The pectoral fins were firmly attached and very large, the ventrals are somewhat less. The dorsal fin extended nearly the whole length of the back, encircled the tail, and was continued along the ventral surface: it was supported by ossified spinous and interspinous processes. The vertebræ and crainial supports were cartilaginous, the latter with innumerable osseous centres. My views with respect to the classificatory position and natural affinities of the genus Pleuracanthus have been expressed in papers published in the Annals and Magazine of Natural History (Ser. V., Vol. V., p. 349), and in the Quarterly Journal of the Geological Society (Vol. XXXVI., p. 321), and it need only be further remarked that the comparatively short, tapering body, large broad head with occupital spine, the number of its branchial arches, and the general character of the fins offer a striking contrast to the elongate form, small head, six or seven branchial arches and scanty fins of Chlamydoselachus. The resemblance of the teeth at first insisted upon by Professor Cope is only a superficial one and rests simply on the accidental circumstance of each having three denticles.

In the Palœozoic strata of Britain, with the exception of one

species described by Dr. Traquair, to be mentioned hereafter, the spines of Ctenacanthus have not been found associated with the teeth of Cladodus in such close juxtaposition as to render undoubted their relationship the one to the other. Both the teeth and the spines are found most frequently in the Mountain or Carboniferous Limestone Series. They also occur with tolerable frequency in the Coal Measures above; and spines of Ctenacanthus, or others very similar in form and structure, have been found as low stratigraphically as the Upper Silurian rocks. In the latter no teeth have hitherto been discovered which can be said even approximately to belong to the same fishes as the spines. From the Mountain Limestone of England and Ireland fourteen species of Ctenacanthus have been obtained, and from the same beds twelve species of Cladodus. The larger number in each case have been collected, principally by the indefatiguable exertions of the Earl of Enniskillen, whose magnificient collection now forms part of the National collection at the New Natural History Museum in London; from the limestone quarries in the neighbourhood of Armagh in Ireland whence ten species of Ctenacanthus and eight species of Cladodus have been obtained; from Bristol there exists three species of the latter, whilst at Oreton in Salop, four species of Ctenacanthus have been found, three of which are the same species as those found at Bristol, but no teeth of Cladodus have been discovered. In Yorkshire numerous teeth of Cladodus comprised in four species, occur in one of the Yoredale Limestones which form one of the uppermost beds of limestone in the Carboniferous series, though no trace has hitherto been discovered of the remains of Ctenacanthus spines. In other districts teeth of Cladodus are occasionally found, but the spines of Ctenacanthus are not associated with them. Both are found in the Scotch beds. A comparison of these facts exposes some peculiarties; for whilst in the limestones of Armagh and Bristol, the relative proportion and occurence of the two genera is nearly equal, there is the phenomenon in the Yorkshire series of four species of Cladodus being in existence without spines of Ctenacanthus and *vice versa* in Salop. It is not probable that these pecularities occur in consequence of want of investigation, because, in the Yorkshire beds at any rate, the quarries

have been most carefully and assiduously watched for more than twenty years, and if spines of Ctenacanthus had been present they would certainly have been collected. Altogether between thirty and forty species of fossil fishes, other than those already named, have been found in the beds which it is probable belonged to the fish Cladodus. Associated with the Ctenacanthus spines at Oreton in Salop there are numerous teeth of Orodus, but there is no evidence except the fact of their association which would lead to the inference that they might have existed together as part of the living fish.

A remarkable contribution to the knowledge of the genus Ctenacanthus was made by Dr. R. H. Traquair in the Geological Magazine (Decadi III., Vol. I., p. 3). He there describes a fossil shark from the Lower Carboniferous beds of Eskdale in Scotland, now in the Natural History Museum, London. The length of the fish is 28 inches and its greatest depth 5 inches: it possesses two dorsal spines situated in front of fins which occupy the same relative position as do those of the Hybodus of the Lias. The anterior spine is four-and-two-thirds, and the posterior one, four inches in length. The verterbal axis and the head were cartilaguous, the latter much crushed and not well defined. The only distinctly visible tooth is detached from the jaws; it is one-eighth of an inch in length, and consists of a single smooth denticle with an expanded base which Dr. Traquair considers *might* support lateral denticles.

In the Coal Measures, separated from the Carboniferous Limestone by the Millstone Grit series, in some localities attaining a thickness of between one and two thousand feet, the spines of Ctenacanthus are almost universally common, and indicate a fish of large size; but teeth of the Cladodont type are rarely found, and in some districts are entirely absent. In the Scotch Upper Coal Measures the spines and teeth occur, and have been attributed to about an equal number of species of each genus respectively. In the Yorkshire coal field three species of Ctenacanthus have been determined, but no well-defined teeth of Cladodus have been recorded. Teeth have been found which approach to some extent the Cladodont type, they have a broadly expanded base with several cones arising therefrom, the central one the largest, one-third the length of the

base in height, with two or more lateral denticles diminishing in size as they recede from the central one. They approach in form more nearly to the Hybodus of the Lias than to the Cladodus of the Mountain Limestone.

After the deposition of the Coal Measures the place of the Cladodont is taken by the Hybodonts of the secondary rocks. Cladodus so far as we know became extinct.

A consideration of the foregoing observations shows that with the exception of *C. costellatus,* Traq., there is nothing definitely known as to the structure of the genus Ctenacanthus. Dr. Traquair's species demonstrates clearly the form of the fish which carried the Ctenacanthoid spines, but unfortunately the evidence is not so clear with regard to the teeth. The tooth exhibited on the specimen may be a Cladodus, but the imperfection of its somewhat contracted base and the absence of all, except the central cusp, leaves room to doubt its identity. At the same time in reviewing the fossil teeth of the lower limestone, it must be admitted that there is probably no other genus which possesses a denticular arrangement similar to *C. costellatus*, Traq., and this forms an argument in favour of the opinion of Dr. Traquair. There can be little doubt, however, that the light thrown by this specimen on the external form of the Ctenacanthoid fishes proves their close relationship with the Hybodonts of the secondary formations.

Mr. Garman defines the position of Chlamydoselachus in the system of recent sharks as near the genera Hexanchus and Heptabranchias. The structure of the brain and its possession of six branchial appertures clearly remove it from all others, and as it differs more than they do from other sharks, it lies further from the main body of the Galei. The shape of the body, position of the mouth, articulatians of the jaws, dentition, squamation, lateral line, pelvis, tail and tropeic folds, furnish characters sufficient to establish the distinctness of both genus and family. Its rank is determined to be somewhat lower than Notidanus by its unsegmented notochord, elongated bulbus and numerous cardiac valves, chondrification and other particulars, whilst certain cephalic peculiarities and the shagreen associate it remotely with Squatina, and its position falls

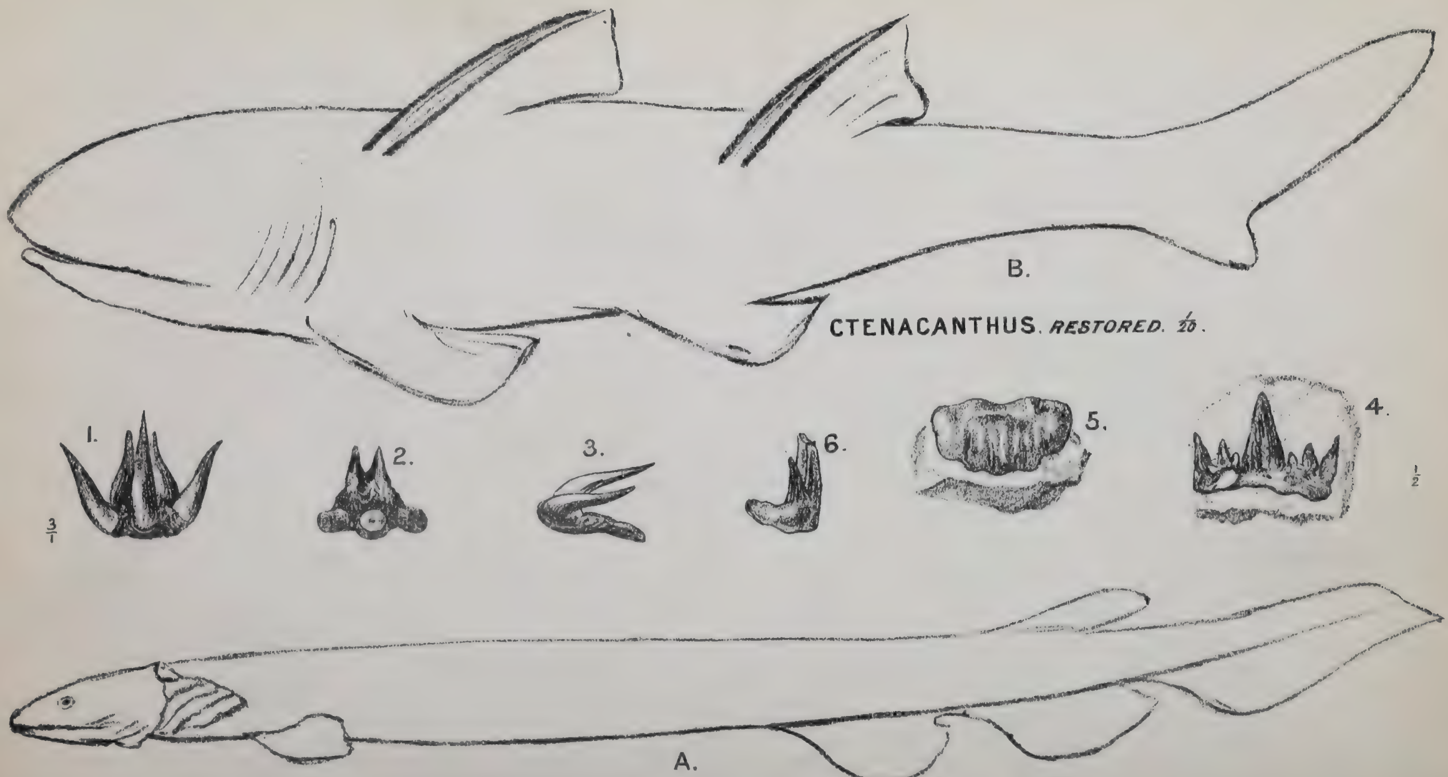
naturally between these two genera. But its relationship with existing forms is considered of minor importance when compared with its "close affinity to the genus Cladodus." From first mentioning the genus Mr. Garman has insisted on its resemblance to Cladodonti. "A further study of both extinct and recent forms enables me to speak still more positively in asserting that Chlamydoselachus *is* a Cladont. As shown in the description above, some of its teeth are so characterized as to make it imperative, if these teeth are alone considered, that the species should be placed in the genus Cladodus of Agassiz, and nearer than almost any of the fossil forms to his type *C. mirabilis.*"

It remains now to be considered whether the teeth of Chlamydoselachus are so closely related to those of Cladodus as to warrant their inclusion in the same group. The possible relationship of Ctenacanthus and Cladodus being for the moment disregarded, the teeth comprised in the Cladodont family exhibit a very considerable variety of form, but there are certain characters which appear in all, these may be defined in the broadly-expanded, horizontal, thick osseous base, semicircular behind, truncated in front: from the truncated margin rise a varying number of sharp conical points or denticles at right angles to the base. The median cone is the largest and the two external secondary ones are larger than the intermediate ones where such exist. *Cladodus mirabilis*, Agass., may be taken as the type of its genus. It is a large powerful tooth, with strong central cone and two or three secondary ones on each side, the posterior expansion of the base is probably larger in this species than in any other. In the Enniskillen collection now at the Natural History Museum, in London, there are two species of Cladodus, named respectively, *C. curvus* and *C. destructor*, described in the Trans. of the Royal Dublin Society (Vol. I., Ser. II., p. 376, pl. XLIX., figs. 14, 15). The former consists of three curved pointed denticles attached to a somewhat slender base, the posterior portion of which is hidden in the matrix, and consequently it is impossible to say whether it possesses the expanded base characteristic of the genus or not. *C. destructor* is similarly composed of three conical denticles, thicker in proportion to their length than

those of *C. curvus.* The base is large and thick, extending backward with a slight obliquity (op. cit., fig. 16). So far as the writer is aware, amongst British species the one or the other of the two last named appears to approach most nearly in external form to the teeth described by Mr. Garman. The author has referred to the American genera Pternodus (Pristicladodus, St. John and Worthen) and Trinacodus, St. J. and W., both from the Kinderhook fish beds, and more or less allied to the genus Cladodus (see Geological Survey of Illinois, Vol. VI.), and suggests that they may constitute an intermediate link between the form of Cladodus and the new genus.

There is then on the one hand the fossil teeth having a horizontal base with rounded posterior margin and erect denticles three or more in number; and on the other, the existing shark with teeth of varied forms, the more important of which have a broad base, whose posterior margin is prolonged into a pair of prongs which extend beneath the contiguous tooth. Three denticles spring from the anterior part of the base, equal in size, and bent backwards over the base with which they form a more or less acute angle. These teeth differ greatly from the type of *Cladodus mirabilis*, Agass., but others occupying a position more remote from the symphysis of the jaws have a different form, the denticles, three in number, are erect, and the lateral ones are smaller than the one in the middle; the resemblance in this instance is very close to the teeth of the fossil Cladodus, but again, other teeth still more remote lose the lateral or secondary denticles and have only a single median cusp.

Our knowledge of the fossil forms of Cladodus does not lead us to infer that the teeth of Cladodus differed in form to any extent comparable with those of the existing Chlamydoselachus. There are no fossil examples known to be associated with the ordinary form of Cladodus similar to those of either the anterior recurved teeth or the posterior ones with a single denticle as in the recent fish, and the question naturally arises as to whether the correspondence in the form of one portion of the teeth of Chlamydoselachus is sufficient to justify the assumption that the latter is the existing



CTENACANTHUS. *RESTORED.* 1/20.

CHLAMYDOSELACHUS ANGUINEUS. *CARMAN.* 1/10.

type of a group of sharks hitherto considered to be extinct since the Carboniferous period. The resemblance is no doubt striking, and the discovery of intermediate forms in the secondary or tertiary formations will be a great assistance in guiding the palæontologist to a correct estimation of its value, but at the present no such evidence exists, and whilst the immense value of the discovery of the fish cannot be too fully appreciated, it may be well to await fresh evidence before finally deciding that Chlamydoselachus is a descendant from the fossil Cladodonts.

Explanation of Plate XI.

Fig. A. Chlamydoselachus auguineus, Garman.
,, B. Ctenacanthus, *restored.*
,, 1. Tooth of Chlamydoselachus auguineus.
,, 2. Ditto. showing base.
,, 3. Ditto. lateral view.
,, 4. Tooth of Cladodus mirabilis, Ag.
,, 5. Ditto. base of another specimen.
,, 6. Ditto. lateral view of same.

ON THE PHYSICAL GEOGRAPHY AND GEOLOGY OF THE EAST RIDING OF YORKSHIRE. BY REV. E. MAULE COLE, M.A.

The East-Riding of Yorkshire is bounded on the East by the North Sea, on the South and West by the Humber and Ouse as far as York, thence to Stamford Bridge by the road to Garrowby Hill, after which the boundary follows the course of the River Derwent to its junction with the Hertford, the latter rivulet forming the boundary as far as Muston Carr, where a line is made for a ravine which separates Filey Church from the old fishing town of Filey.

This area, small as it is, contains within itself for the geologist, ornithologist, and botanist probably greater scope for research than any equal area in England. Geologically it consists of all the various formations from the New Red Sandstone upwards, including the Lias, Oolite, and Chalk, whilst nowhere are the Boulder Clays of the Ice Age so well developed. The grand precipitous Chalk Cliffs of Bempton, 400ft. high, are the favorite breeding place of tens of

thousands of guillemots and razorbills, whilst pigeons, jackdaws, kittiwakes and puffins find here also a congenial home for the rearing of their young.

As a contrast to this may be mentioned the curious sandy promontory of Spurn, some 4 miles long, and 200 yards wide, at the mouth of the Humber, raised only a few feet above the sea level, which, though once supposed comparatively devoid of life, has proved of extreme interest both to the botanist and zoologist.

Here, too, on the Yorkshire Wolds, you meet with the narrow ramifying dales, extending for miles, with their steep sloping sides, and level grassy bottoms, a sight unique in England. Coloured on a map they look like branches of a tree. No water flows in them, either above or below the surface, yet in all probability their excavation is due to the rainfall, acting partly in lines of faults, and partly in fissures, caused by the drying and contraction of the Chalk when elevated above the sea. It is well-known that the rainfall acts with more denuding effect on the bottom and sides of a valley than on a level surface, and consequently that valleys deepen faster than a level surface is lowered; hence the inequality of surface is slowly, but continually on the increase. At present the top of some of the dale sides is 200 feet above the bottom.

The high land out of which these are carved attains a height of 800 feet. This elevation is reached at Garrowby Hill top. Eastwards, towards the sea, the elevation drops to about 400ft. at Bempton, whilst southwards, towards the Humber, the top of the chalk quarry at Hessle is little more than 80ft. above sea level. The Wolds before the Inclosure Acts, some 90 years ago, were the resort of numerous rare birds, notably the Great Bustard which is now extinct in England.

As may be supposed the Wolds form a watershed, or water-parting, between the Vale of Pickering, the Vale of York, and Holderness, but the rain which falls upon them re-appears under different conditions. Chalk is very porous, and holds water somewhat like a sponge; so much so, that the line of saturation underground actually follows the contours of the hills. This has been proved by Mr. J. R. Mortimer by a careful measurement of the wells in dry

and wet seasons. The main dip of the Chalk is towards the south-east; hence the greater portion of the rain which falls over an area estimated at 420 sq. miles finds its way to Holderness, but there it meets an impervious sheet of Boulder Clay, lying on the surface of the Chalk, through which it cannot possibly rise except by means of Artesian Wells. Consequently, when the Chalk strata below are fully charged with water, springs burst out at the edge of the Boulder Clay which are mostly perennial. Sometimes, as at Kirkburn, they cease altogether during a dry season, whilst at other times, during a wet season, they accumulate such force as to burst through a solid highroad. These peculiar outbursts of water are known by the name of "Gypseys," and the flow of water is called the "Gypsey-race," another peculiarity of the East-Riding.

At the northern and western sides of the Wolds there is a copious discharge of water from the innumerable springs, which burst forth at the junction of the Chalk with the underlying clays, whether Kimeridge or Lias. This line of junction occurs at varying heights, but attains its maximum above sea level at the north-west corner of the Wolds, at an elevation of about 500 feet. Hence the mass of the Chalk Wolds, east and south of this point, is shown to be composed not of Chalk, but of earlier rocks thrown up millions of years ago, in an anticlinal stretching probably through Harrogate from Lancashire, and subsequently denuded before the area in question formed the bottom of a Cretaceous sea.

There are but two rivers worthy of the name, and even that is saying a great deal, namely, the Derwent and the Hull. The former rises in the heart of the Moorlands to the north and, having cut through the gorge of the Forge Valley, is joined in its progress through the Vale of Pickering by a number of streams coming down from Newton Dale, Rosedale, Farndale, Bransdale, and Bilsdale, besides the becks issuing from the Chalk Wolds on the south, and a second time cuts through a barrier of Oolitic rocks, and finds its way into the Vale of York, where eventually it joins the Ouse. The other river, the Hull, rises somewhat promiscuously. It is difficult to say where its origin is, in consequence of the "Gypseys." The streams which contribute to it burst out from the edge of the clay

mantle already alluded to as covering Holderness. In the neighbourhood of Driffield they combine sufficiently to attain the dignity of a river capable of floating a barge.

The drainage of Holderness is not, as might be supposed, towards the coast, but towards this river in the centre, which finds its exit in the Humber, at a place which has now usurped the name of the river, being called Hull, whereas its proper designation is Kingston-upon-Hull.

Holderness was formerly a land of water; and like the polders of Holland, the water of the drains has to be pumped out by mechanical agency. One stream in the East-Riding succeeds in finding its way direct to the North Sea, but not in a gentlemanly way. It hides its diminished head underground between Butterwick and Rudston. Rising at Wharram-le-Street, it flows through Duggleby, Kirby Grindalyth, The Luttons, Helperthorpe and Weaverthorpe (which latter place has been flooded occasionally to a serious extent) till, taking advantage of the gravels which form the valley bottom, it disappears at Butterwick, and, reappearing at Rudston, where the celebrated Monolith is, finds its way past Boynton to Bridlington Harbour.

On the north and west side of the Wolds springs burst forth at various levels, as before stated, and help to swell the waters of the Derwent in its course towards the Humber.

There are few lakes or sheets of water in the East-Riding: the principal one is Hornsea Mere, which is nearly two miles long, and about three-quarters of a mile wide.

There are several sandy tracts, known as commons, which are chiefly met with in the Vale of York, and occur also at Ganton in the Vale of Pickering, and at Burythorpe.

There are also numerous low-lying districts in Holderness and the Vale of Pickering, subject to periodical flooding, known as Carrs. In the Vale of York they would be called Ings.

In the neighbourhood of Sledmere there are very extensive woods composed principally of larch, fir, and beech; otherwise the high ground is comparatively destitute of trees. In all probability the Wolds for ages formed an area of open ground, surrounded by

low-lying swampy districts, covered with thick forests, which afforded hunting-grounds for the people who lived on the hill tops. The vast entrenchments on the Wolds, and the great number of tumuli show that in ancient British days the high grounds were thickly populated, whilst even in later days the same fact is borne witness to by the number of sites of extinct villages.

The following Geological Formations occur in the East-Riding:—

Sand Dunes	Recent and Post-glacial.	Post Tertiary.	
Warp			
Chalk Gravels			
Peat			
Sands			
Boulder Clays and Gravels	Glacial.		
Upper Chalk	Upper Cretaceous	Cretaceous.	Secondary.
Middle ,,			
Lower ,,			
Speeton Clays	Lower Cretaceous		
Kimeridge Clay	Upper Oolite.	Jurassic.	
Upper Calcareous Grit	Middle Oolite.		
Coral Rag			
Coralline Oolite			
Lower Calcareous Grit			
Oxford Clay			
Kelloway			
Millepore	Lower Oolite.		
Estuarine Sandstones			
Dogger			
Upper Lias			
Middle Lias			
Lower Lias			
Rhætic			
Keuper	Upper New Red Sandstone.	Triassic.	

The point of junction between the Bunter Sandstone and the variegated coloured marls of the Keuper lies somewhere about the longitude of Goole. A portion of the East-Riding is therefore undoubtedly underlaid by the Bunter, but as this is covered throughout with a modern deposit of boulder clay, alluvium and recent warp to a depth of from 50 to 100ft. it may be passed over. The Keuper appears at the surface at Holme-on-Spalding Moor; in two low hills, at the base of the Wolds, between Kilnwick Percy and Burnby; and in the becks about Bishop Wilton, Bugthorpe, and Leppington.

The Keuper marls run right up to Acklam Wood, and have been quarried for gypsum between Skirpenbeck and Scrayingham. The red and white mottled sands are very picturesque. This is the formation which in Cheshire contains rocksalt. It has not as yet been sought for in the East-Riding.

The paper shales of the Rhætic may be seen in the sides of the becks just above Bugthorpe, and at Acklam Wood, also at Howsham, and below Millington, but are not exposed to any extent on the surface.

The lower beds of the Lias extend from Howsham to the Humber in an unbroken line of moderate width of from one to two miles. The largest exposures are between Westow and Garrowby. The district known as the Abbey lands, immediately south of Westow, consists of Lower Lias. Thence the beds extend from Howsham to Acklam, and westwards again to Leppington. Thence southwards they surround on three sides, first, Barthorpe Bottoms, and then Bugthorpe. From Garrowby Street to Market Weighton they form the sloping hill sides of the Wolds, and are traversed by many streams, issuing from the line of Red Chalk, which in several cases have cut back deep valleys in the western escarpment of the Chalk, as at Givendale, Millington and Warter, exposing the Lias in the bottom. South of Market Weighton the Lias leaves the Chalk range, and forms a prominent escarpment of its own, in the neighbourhood of North and South Cliff. It is here that the lowest beds of all, the *A. planorbis* zone, can be better studied than in any other part of Yorkshire.

In the same district Oolitic rocks form a narrow band between the Lias and the Chalk. Two ridges are apparent, the westernmost consisting of a blue-hearted limestone, called Cave Oolite, and probably identical with the Millepore Limestone of the Coast, the other of Kelloways Sand Rock. At Grimthorpe and Kirby Underdale are outliers of Millepore, with a few Estuarine Sands. Thence northwards for a distance of six or seven miles we come across a belt of Oolitic rocks, a prolongation of the Howardian range, terminating at North Grimston. This area may be expected to yield a flora of its own.

In the south-west corner, the Dogger, Estuarine Sandstone, and Millepore, or Whitwell, Limestone are exposed at Kirkham, Firby, Westow, and Burythorpe, whilst in the centre, by Fox Cover Plantation, is a mass of Kelloways rock weathered into an unproductive bed of sand on the surface. In the south-east corner, the Lower Calc. Grit, resting on Oxford Clay, appears at Acklam Brow, Leavening, and Birdsall, with a belt of Kimeridge Clay between it and the Chalk, which said clay forms also a triangular mass north of Birdsall, with its apex at Kennythorpe, and base underlying North Grimston Wold. In the north-west, Kennythorpe, Langton, and Menethorpe are on Lower Calc. Grit, cut through in places by streams down to the Oxford Clay; whilst in the north-east, North Grimston, Settrington, and Langton Wold present fine sections of Corallian rocks. Indeed, the finest display of coral reefs in England is acknowledged to be at N. Grimston. Here also supra-coralline beds of hydraulic limestone, forming an excellent cement, are well developed.

From Acklam Brow eastwards to Knapton Wold, Kimeridge Clay forms the sides of the Wolds, and has given rise to numerous landslips: indeed, this clay everywhere underlies the Chalk on the northern slopes of the old anticlinal; for in Thixendale denudation has cut right through the Chalk, and exposed the Kimeridge Clay in many places. Burdale tunnel, 400ft. above sea-level, was chiefly excavated in this clay, which may be seen forming the sides of the valley up which the railway runs from N. Grimston to Burdale. At Huggate, however, the Chalk rests immediately on Lias, as proved

by sinking a well to a depth of 300ft. Of course the Vale of Pickering is a mass of Kimeridge Clay 400 to 500ft. deep, but as this is covered up with alluvial deposits, it suffices to mention the fact.

The Speeton Clay, which is a marine formation equivalent to the fresh-water deposits of the Wealden in the South of England, occupies a corner in the extreme north-east of the East-Riding. Here a fairly large portion, half-a-mile in length, is available for investigation, and so well has it been studied by Professor Judd, that three distinct zones have been mapped, each containing characteristic fossils. Strips of this clay appear along the northern edge of the Wolds from Ganton to Knapton. In Painsthorpe Dale, near Kirby Underdale, there is another exposure of Neocomian age, but in this case the rock is a coarse irony sandstone.

In the south, beds of the horizon just mentioned are followed by Gault and Upper Greensand, but in the north they are absent. The rock which immediately rests on Speeton Clay is Red Chalk. This appears to underlie the whole Chalk area of Yorkshire and Lincolnshire. Wherever the Red Chalk appears on the sides of the hills there are the springs. This is noticeable as the line of moisture is an important factor in botanical or conchological research.

Grey Chalk succeeds, and is partially intermixed with the Red Chalk, and both are followed by a thin band of Black Chalk, with vegetable and animal remains, which forms a boundary line between these somewhat argillaceous bands and the flint-bearing White Chalk. The greater portion of the surface of the Wolds is composed of this middle flint-bearing chalk. All round the northern and western edge the flints lie on the ground in such profusion, that it is a matter of wonder how a blade of corn can pierce its way upwards. In many cases the flints are gathered up by hand, but the supply is almost inexhaustible, and the benefit doubtful when done.

There is a narrow district extending from Flamborough Head through Burton Agnes and Cottam to Wetwang, thence south to Beverley, where the Upper beds of the Chalk appear. These contain no flints, but there is a larger proportion of Silica in the

mass than in the lower flint-bearing beds, as ascertained by Mr. J. R. Mortimer. Chalk is extremely porous and the rainfall sinks rapidly through the mass: at the same time the heat of the sun draws the moisture to the surface, so that even in dry seasons there is far more moisture for the delicate fibres than in many other soils.

The Chalk cliffs at Bempton, Buckton, and Flamborough present some of the finest coast scenery in England. During the breeding season they are covered with innumerable hosts of sea-birds, who think it the height of felicity to scream and squabble at the top of their voices. It has one good effect: in a fog you know where you are; which is encouraging. It would be a good thing to extend the close time for shooting another month, as now many a poor young bird is starved to death; besides, the birds might then all get away, and it would encourage trade to fire at bottles instead of birds. They would be just as bad to hit bobbing away on the waves, which is all the *sportsmen* want.

The East-Riding, in common with the North of England, has, with perhaps a temporary submergence during the Glacial age, been dry land thoughout the Tertiary Period. During this vast period the whole of the Nummulitic Limestone which extends from the Pyrenees to the Himalaya, and is many thousand feet thick, was being deposited beneath the sea. But no trace of any later rock than the Chalk occurs in the East-Riding till we come to the Ice Age. Then an enormous glacier, originating in the mountains of Scandinavia, spread itself over the present area of the North Sea, and pushed before it the mass of Boulder Clay, which forms the surface soil of Holderness, to a depth, at Hornsea, of upwards of 130ft, and which even caps the tops of the Chalk cliffs at Bempton.

A stream of ice coming down the East Coast from Scotland, as well as from the high grounds of the Pennine range, overpowered by its mighty neighbour from the north-east, pressed against the Chalk Wolds, and covered all Holderness with a mantle of Boulder Clay; not once, or twice, but many times: so that this wide district presents a character of its own, scarcely to be met with elsewhere.

The conformation of the ground lends its aid, as the lowest part of the area is not on the coast, but, landwards, towards the centre of

the district drained by the river Hull. Consequently in former times large portions of Holderness were under water, and even now are liable to be extensively flooded.

Beds of extinct fresh-water lakes are by no means uncommon, and are easily recognisable by the whiteness of the clay.

Hills of sand and gravel, some containing crushed arctic shells, others, shells now confined to warm climates, as *Cyrena fluminalis*, are also frequent. They are almost invariably covered with a coating of Hessle Boulder Clay.

Huge trunks of trees, occasionally found embedded in peat, show that the district was once covered with forest growth, subsequently to the disappearance of the ice, and the submerged forests on the shore at Hornsea, and at Hull tell the same tale.

On the side of the Vale of York there is comparatively little Boulder Clay. What there is does not extend much south of Escrick. There are, however, some extensive sandy tracts, known by the name commons, as Skipwith, Allerthorpe, etc., dating from the same age. In the Vale of Pickering, near Ganton, there is a wide district of sand, apparently Oolitic in its origin, derived from the Tabular Hills and Moorlands to the north, having been brought down Forge Valley by the River Derwent, and spread over the surface.

We must not omit to mention that a large part of the East-Riding, in the neighbourhood of Spalding Moor, drained by the river Foulness, was once a morass, and that extensive accumulations of peat took place, which, from the absence of lime in them, were, and are, unsuitable for the growth of mollusca.

On the west side of the Wolds, especially in the neighbourhood of Pocklington, a quantity of chalk gravel forms the subsoil, though removed a considerable distance from the present Chalk Escarpment, and conveyed over beds of older date.

On the low grounds near the Humber and Ouse the tidal wave deposited great quantities of warp, especially before the rivers were embanked. This warp forms a fertile soil. It appears to be fine mud washed out of the Boulder Clay on the coast, and carried with the tide up the rivers. It differs materially from the sediment brought down by the rivers themselves.

Sand is sometimes accumulated by the wind into heaps which are then known by the name of dunes. Such dunes are common on the Lancashire coast, and notably in Holland. In the East-Riding they occur at a peculiar point of land, known as Spurn Point. This is a sort of natural embankment, 4 miles long, and very narrow, bounded by the sea on one side, and by the Humber on the other. It is mainly composed of shingle washed out of the Boulder Clay, which is ever travelling southwards; the whole being capped with fine sand, which forms a congenial home for certain marine plants, whilst the shingle provides a breeding place for terns.

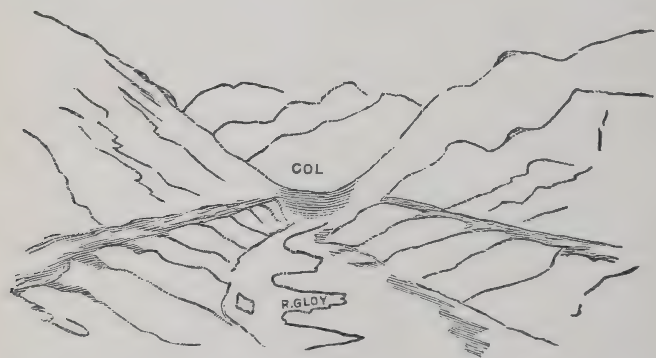
At the lighthouse at Spurn Point, many interesting notes have been taken with respect to the migration of birds, which have been embodied in a report given to the British Association, in 1883, by Mr. John Cordeaux.

NOTE ON THE PARALLEL ROADS OF GLEN GLOY. BY REV. E. MAULE COLE, M.A.

Visiting this year some friends on Loch Lochy, a portion of the Caledonian Canal, I had an opportunity of examining carefully the parallel roads of Glen Gloy, over which my friend's shooting extended. Little has been written about Glen Gloy, though a good deal more has been said about its more illustrious neighbour Glen Roy.

A good summary of the literature on the subject of the parallel roads will be found in Sir C. Lyell's Antiquity of Man, with a map and sketch. Since then Mr. J. R. Dakyns, of H. M. Geological Survey, has published some notes in the Geological Magazine for December, 1879, which he kindly sent me, wherein he alludes to a paper by Professor Prestwich on the same subject, published in the July number of the Geological Magazine of the same year, and also to a paper by Sir John Lubbock, in the Q. J. G. S. for 1868, neither of which have I seen.

The parallel roads of Glen Gloy are higher than the top-most of the three in Glen Roy, being at a pretty uniform elevation of 1,165ft. above sea-level, whereas, those in Glen Roy are 1,149, 1,068, 857ft. respectively. They point directly for a col leading to Glen Turret and Glen Roy, the height of which is given as 1,172ft. There can be no question whatever as to the principal facts. That the roads or terraces are the shore margins of a former loch, whose waters drained over the above-mentioned col to Loch Spey; that the loch was subsequently emptied somewhat rapidly, and converted into a glen, with a river running in the opposite direction to Loch Lochy; and that nothing has since affected the roads except subaerial denudation.



There are, however, some particulars in which they seem to differ from the descriptions given of the roads in Glen Roy, and which I wish to place on record. Of the latter, Lyell writes: I.—"When we are upon them, we can scarcely recognise their "existence, so uneven is their surface, and so covered with boulders, "they merely differ from the side of the mountain by being some-"what less steep. And II.—"they have not been caused by denudation, but by deposition of detritus," and he quotes Darwin as affirming that the roads are "mere excrescences of the superficial "alluvial coating which rests upon the hill-side."

Now in Glen Gloy, at the upper end for a couple of miles, the terrace on the west side is so level in many places that several carts could be driven abreast. In one place in particular, at a point where

a burn had caused a fine delta to be formed, there was level space enough, 35 yards wide, to play a game of croquet on. Only in a few places was the surface uneven from the boulders, and the difference of slope from the side of the mountain was uniformly considerable. Next they were caused partly by denudation; for in one very fine section, where the rocks were standing on their edges, exposed in the side of a large corrie, the tops of the beds had evidently been planed away, before the ordinary detritus had accumulated; and therefore the terraces are not "mere excrescences." They are cut in the solid rock in some places at all events. Mr. Dakyns comes to this conclusion too; for he says, "How then "were the roads formed? Obviously by the planing action of waves "acting on the rock and cutting the shore-line back." But then he goes on to say, "subsequently, on the lowering of the water-line, "the detritus of the mountain side falling, and being washed down "hill by rain, etc., lodged on the platform of the shelves, and there "accumulating gradually formed a pile of loose material sloping "towards the valley, and slowly obliterating the true roads."

Now, here, I do not quite agree with him, or rather, I should say, the facts relating to the roads in Glen Gloy do not bear out the observations made in Glen Roy. In all probability the sides of the hills in Glen Gloy are not so steep, and have been more rapidly covered with vegetation than those in Glen Roy, and hence the roads have not suffered so much from detritus. They are more in their original condition.

This being so, it is clearly a matter of interest to describe what this condition is.

The roads are shelves in the mountain sides, from 10 to 12 yards wide: in some cases, where a delta has been formed, from 30 to 40 yards wide. They are nearly level, scarcely averaging 1ft. in 20ft. in slope. They point directly for the col at the head of the glen. They are deeply furrowed by burns descending the mountain's side. These burns helped to form the roads when the loch was in existence. The steepest portion of the hillside is that immediately below the roads. The material brought down by the burns was arrested by the water, and was invariably, then, as now, carried to the eastward

by the prevailing winds. Every burn has its delta, and every delta is on the east side of the burn. Examine the burns and deltas on the shore-line of Loch Lochy in operation now: exactly the same phenomena are apparent as in the parallel roads of Glen Gloy. So that I have come to this conclusion, that the roads were formed in a comparatively tranquil loch, not in an arm of the sea; at a time when the ice sheet had passed away, and subsequent to any submarine depression; formed, partly, by the grinding of shore ice, and, partly, by the accumulation of detritus brought down by the existing burns, and left in a heap at the margin of the water; that this detritus was constantly carried by the prevailing winds to the eastward of the burn to which it owed its origin, and then frequently spread out into a small level platform by the waves. Subsequently the loch was drained by the removal of the temporary barrier, either a moraine, or more probably a glacier, as so ably argued by Lyell, and the burns continued their downward course, cutting more deeply into the mountain sides, and carrying the debris to the level of the river. Meanwhile, the roads have naturally been the receptacle of loose stones and boulders, which, in places, have partially destroyed their symmetry.

SECRETARY'S REPORT.

THREE meetings of the members of the Society have been held during the year. The first was at Malton in the East-Riding, on Wednesday, July 8th, 1885. The members first proceeded from Malton to Settrington and North Grimston, where Mr. C. Fox-Strangways, of H. M. Geol. Survey, pointed out and explained the Geological features of the district. Several quarries in the Coralline Oolite were visited and fossils obtained. At 2 p.m., the party returned to Malton, and after dining at the Talbot Hotel, the meeting was held in the same house. Papers were read by the following gentlemen:—Mr. J. R. Mortimer, of Driffield, Rev. E. Maule Cole, M.A., of Wetwang, Rev. J. Stanley Tute, B.A., of Markington, Messrs. W. Y. Veitch, of Middlesbrough, G. Robert Vine, of Sheffield, and H. B. Stocks, of Halifax. In the absence of Sir Chas. W. Strickland, the Rev. E. M. Cole occupied the chair. At the conclusion of the meeting, those present visited the Museum, under the guidance of Messrs. Chadwick and Slater of Malton.

The second meeting was held in the Lecture Theatre of the Yorkshire Philosophical Society, at York, on Wednesday, the 9th of September. The President, the Marquis of Ripon, K.G., occupied the Chair. He received a very hearty reception, and congratulations on his successful occupancy of the position of Viceroy of India during the last five years. His Lordship delivered an address on the Work and Progress of the Society. Papers were read by Messrs. G. W. Lamplugh, of Bridlington, James W. Davis, of Halifax, G. R. Vine, of Sheffield, and T. Carter Mitchell, of Thirsk. After the meeting, the members dined at the Station Hotel; the Marquis of Ripon presiding.

The third meeting was held at the Museum of the Literary and Philosphical Society, at Leeds, on Wednesday, October 28th, 1885. The Rev. E. Maule Cole occupied the Chair. The business of the annual meeting was transacted, and papers read by the Chairman and Mr. James W. Davis.

The Society, whilst still maintaining its popularity and prestige, has been more than usually unfortunate in the loss of fourteen members, nine of whom have withdraw from the Society, and the remaining five have been removed by death. The latter number comprises the names of John Dunning, F.G.S., of Middlesbrough, John Haigh, J.P., of Dewsbury, and E. Maude, of Middleton Hall, near Leeds, elected a member in December, 1855, Viscount Halifax, of Hickleton Hall, near Doncaster, and Lord Houghton, of Fryston Hall, near Pontefract.

Lord Houghton, M.A., D.C.L., F.R.S., &c., was a member of the Society from the year 1845, and was forty years a Vice-President; he took an active interest in the Society, and presided at a meeting at Wakefield, in 1878. In the early history of the Society, Richard Monckton Milnes was a prominent and accomplished figure at the meetings of the members.

Viscount Halifax was elected a member of the Society as Chas. Wood, Esq., M.P., on August 1st, 1843. His father, Sir F. S. Wood, Bart., was a member of the Society, and a Vice-President from its institution; on the death of the latter, in 1846, Sir Chas. Wood, M.P., was elected a Vice-President, and almost without intermission he has occupied that position until the time of his death during the present year.

There has been an addittion of seven new members to the Society, and five new members have compounded for their subscriptions and become life members. The number of the latter is now 31, and the total number of members 210.

A reference to the Balance Sheet shows that the Capital Account now amounts to £217 12s. 4d; the balance in the hands of the Treasurer, Wm. Cash, Esq., to the credit of the ordinary Subscription Account is £82 3s. 9d.; and the sum of £46 7s. 2d. remains to the credit of the Fund for the Exploration of the Raygill Fissure in Lothersdale. The latter fund has been increased by a grant of £15 by the British Association for the Advancement of Science.

The exploration of the Fissure has been postponed during the past year, to enable Messrs. Spencer, the proprietors of the quarry, to remove a large mass of limestone which impeded the working of

the fissure. This obstacle has now been removed, and it is hoped that the committee having charge of the work will be able at an early date to successfully resume operations.

Last year, the Photograph was not issued to the members, owing to the fact that a negative which had been prepared, was at the last moment accidentally broken. In pursuance of a resolution of the Council, three Photographs will be sent to each member with the proceedings for the current year. They represent a series of Contortions of large extent in the Chalk Cliffs at Bempton, near Flamborough.

The Society is indebted to the following gentlemen, who have at considerable inconvenience, but to the great advantage of the Society, acted as Local Secretaries:—

Barnsley	Thomas Lister, Victoria Crescent
Bradford	Thos. Tate, F.G.S., 4, Kingston Road, Leeds
Bridlington...	Geo. W. Lamplugh, Bridlington Quay
Dewsbury	P. F. Lee, West Park Villas
Driffield	Rev. E. Maule Cole, M.A., Wetwang
Halifax	Geo. Patchett, Junr., Shaw Hill
Harrogate	R. Peach, Harrogate
Huddersfield	P. Sykes, 33, Estate Buildings
Leyburn and Wensleydale	Wm. Horne, Leyburn
Selby	J. T. Atkinson, Selby
Thirsk...	W. Gregson, Baldersby, nr. Thirsk.
York	H. M. Platnauer, The Museum.

The proceedings and memoirs of the learned Societies, whose names are appended, are forwarded to this Society; in exchange our proceedings are forwarded to them. The thanks of the Society are due and hereby tendered to those Societies for their respective contributions.

Essex Naturalists Field Club.
Norwich Geological Society.
Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.

United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.
Birmingham Natural History and Microscopical Society.
Bristol Naturalists Society.
Leeds Geological Association.
Patent Office Library, London.
Powis Land Naturalists Club.
American Philosophical Society.
Comité Geologique de Russie.

The attention of the members is drawn to the Elizabeth Thompson Science Fund.

This fund, which has been established by Mrs. Elizabeth Thompson, of Stamford, Connecticut, "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $25,000. As the income is already available, the trustees desire to receive applications for appropriations in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the trustees to give the preference to those investigations, *not already otherwise provided for*, which have for their object the advancement of human knowledge, or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance.

Applications for assistance from this fund should be accompanied by a full statement of the nature of the investigation, of the conditions under which it is to be prosecuted, and of the manner in which the appropriation asked for is to be expended. The applications should be forwarded to the Secretary of the Board of Trustees, Dr. C. S. Minot, 25 Mt. Vernon Street, Boston, Mass., U. S. A.

Statement of Receipts and Expenditure of Yorkshire Geological and Polytechnic Society, 1884-5.

Receipts.	£	s.	d.	Paid.	£	s.	d.
To Subscriptions	78	11	4	By Cash paid to Bank	78	11	4
„ Bank	64	16	3	„ Printing, Photographs, &c.	64	16	3
	£143	7	7		£143	7	7

THE TREASURER IN ACCOUNT WITH THE BANK.—GENERAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance from last Account	67	1	9	By Cash from Bank	64	16	3
„ Cash paid to Bank	78	11	4	„ Balance at Bank	82	3	9
„ Interest	1	6	11				
	£147	0	0		£147	0	0

CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance from last Account	177	4	7	By Balance at Bank	217	12	4
„ Subscriptions	37	16	0				
„ Interest	2	11	9				
	£217	12	4		£217	12	4

RAY-GILL QUARRY EXPLORATION FUND.

	£	s.	d.		£	s.	d.
To Balance from last Account	30	16	10	By Balance at Bank	46	7	2
„ Subscription	15	0	0				
„ Interest		10	4				
	£46	7	2		£46	7	2

Audited and found correct, H. G. BRIERLEY.

MINUTES.

Meeting of the Council at the Museum, Leeds, May 27th, 1885.

Present, R. Reynolds, Esq. in the chair: Messrs. R. Carter, J. T. Atkinson, G. Paul, J. E. Bedford, W. Rowley, W. Cheetham, and J. W. Davis.

The Minutes were read and confirmed.

Mr. Carter moved, Mr. Cheetham seconded, that following accounts be paid:—

	£	s.	d.
A. Megson & Sons - -	46	10	11½
M. & H. Hanhart - -	3	5	0
	49	15	11½

The Honorary Secretary read a letter from the Marquis of Ripon stating that he would be glad to preside at a meeting of the Society in July.

It was resolved that the Hon. Secretary arrange to hold a meeting to suit the convenience of Lord Ripon, and to suggest that it be held at York.

A General Meeting of the members of the Society was held at the Talbot Hotel, Malton, on Wednesday, July 8th, 1885.

Moved by Mr. R. Carter, seconded by Mr. Slater, "That in the absence of Sir Chas. W. Strickland, the Rev. E. Maule Cole preside." Carried.

The Minutes of the last meeting were read and confirmed.

The following papers were read:—

1. By J. R. Mortimer, Esq., "On the formation of the Chalk Dales of Yorkshire."
2. Rev. E. Maule Cole, M.A., "On some sections of the Hull, Barnsley, and West Riding Railway."
3. Rev. J. Stanley Tute, B.A., "On *Spirangium Carbonarium*."
4. W. Y. Veitch, Esq., L.R.C.P,, &c., "On three new species observed in the Yorkshire Lias."
5. Geo. R. Vine, Esq., "On the Polyzoa and Forminifera of the Cambridge Greensand."
6. Mr. H. B. Stocks, "On the analysis of a Hydraulic Limestone Concretion from the Yorkshire Coast."
7. J. R. Mortimer, Esq., "On a section at Settrington in the Coraline Oolites."

Proposed by Dr. Dunhill, seconded by W. Horne, Esq., "That the thanks of the meeting be given to the Chairman and authors of the papers."

Meeting of the Council at the Museum, York, Sept. 9th, 1885.

The President, the Marquis of Ripon in the chair.

Present, Dr. Alexander, Messrs. Rowley, Reynolds, Fox-Strangways, Platnauer, Bedford, Cheetham, Gregson, Atkinson, Horne, Prof. Green, and J. W. Davis.

The Minutes were read and confirmed.

It was decided that three Photographs be issued to the members this year; subject: Contortions at Flamborough Head.

Proposed by J. T. Atkinson, seconded by Prof. Green, "That the annual meeting be held at Leeds about the end of October."

A *General Meeting* of the members was held at the Museum of the Yorkshire Philosophical Society, on Wednesday, September 9th, 1885.

The President, the Marquis of Ripon, occupied the chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected members of the Society:—

Samuel Learoyd, Sherwood House, Huddersfield.
E. Slater, Ashville, Stanningley, nr. Leeds.
T. Stockdale, Spring Lea, Leeds.
H. M. Platnauer, The Museum, York.
Rev. J. Stanley Tute, B.A., Markington, Ripley.
Wm. C. Gough, Wykeham. York.
Rev. Dr. Pollock, Neville Hall, Middleham Bedale.

M. H. Platnauer, Esq., was elected Local Secretary for York.

The Chairman gave an address on "The work of the Society during the past five years."

The following papers were read:—

1. G. W. Lamplugh, Esq., "On the Glaciation of Alaska."
2. J. W. Davis, "On the Contortions in the Chalk at Flamborough Head."
3. G. R. Vine, Esq., "On the Polyzoa of the Yoredale Rocks of the Northern Countries."
4. T. Carter Mitchell, Esq., "On a stone from the Blue Lias resembling a huge celt."

Prof. Green proposed "A vote of thanks to the Chairman and Authors of papers," which was seconded by Dr. Bowman, and carried unanimously.

Mr. J. W. Davis proposed, and Mr. T. Ormerod seconded "That the

thanks of the meeting be given to the Council of the York Philosophical Society for the use of their rooms."

The members dined together at the Station Hotel, the Marquis of Ripon presiding.

Meeting of the Council, at Museum, Leeds, on Oct. 28th, 1885.

Rev. E. Maule Cole in the chair.

Present, Messrs. Rowley, Atkinson, Cheetham, Tate, and Bedford.

The Minutes were read and confirmed.

The Secretary presented the Annual Report and Balance Sheet which were adopted.

Annual Meeting of the Members in the Library of the Philosophical and Literary Society, Leeds, on Wednesday, Oct. 28th, 1885.

The Rev. E. Maule Cole, M.A. occupied the chair.

The Annual Report and the Statement of Accounts were read by the Hon. Secretary.

Proposed by Mr. Atkinson, seconded by Mr. Cheetham, "That the Report and Balance Sheet be adopted."

Mr. Jas. W. Davis proposed, and Mr. T. Tate seconded, "That the following be elected members":—

Lord Houghton, Fryston Hall.
Viscount Halifax, Hickleton Hall,
Mr. E. Harding, Bridlington. Carried.

A vote of thanks to the Officers for their services during the past year was most cordially carried.

Proposed by Mr. Davis, seconded by Mr. Rowley, and carried, "That the Marquis of Ripon be re-elected president."

Proposed by Mr. Peach, and seconded by Mr. Lister, and carried, "That the following noblemen and gentlemen be elected vice-presidents":—

Duke of Leeds.	Viscount Galway.
Earl of Dartmouth.	Louis J. Crossley, J.P.
Earl Fitzwilliam.	W. Morrison, J.P.
Earl of Wharncliffe.	Thos. Shaw, M.P.
Lord Houghton.	H. C. Sorby, F.R.S., &c.
Viscount Halifax.	Thos. W. Tew, J.P.

W. T. W. S. Stanhope, J.P.

Proposed by Mr. W. Cheetham, seconded by Mr. Atkinson, and carried, "That Mr. W. Cash be re-elected Treasurer, and that Mr. James W. Davis be re-elected Honorary Secretary."

Proposed by Mr. Paul, seconded by Mr. Adamson, and carried,

"That the following gentlemen be elected members of the Council":—

W. Alexander, M.D.	Prof. A. H. Green, M.A.
J. E. Bedford.	Geo. H. Parke, F.G.S.
R. Carter, C.E.	R. Reynolds, F.C.S.
W. Cheetham.	W. Rowley, F.G.S.
J. R. Eddy, F.G.S.	C. Fox Strangways, F.G.S.
T. W. Embleton, C.E.	W. Sykes Ward, F.C.S.

The following papers were read:—

1. "On the parallel roads of Glen Gloy, Scotland." By the Rev. E. Maule Cole, M.A., &c.
2. "Note on *Chlamydoselachus anguineus*, Garman. By James W. Davis, Esq., F.G.S., &c.

Votes of thanks concluded the proceedings.

Summary of Geological Literature relating to Yorkshire, Published during 1885, with addenda for 1884.

Compiled by J. W. DAVIS.

1884.—ADDENDA.

Clarke, T. J. The Yorkshire Caves, a three days trip with the Tyneside Field Club. *Nat. Hist. Trans. Northumberland, Durham, and Newcastle*, vol. viii., pp. 50-67.

De Rance, C.E. Ninth Report of the Committee . . . . for . . . . Underground Waters . . . . *Rep. Brit. Assoc.* for 1883, pp. 147-159.

—————— On the occurrence of Brine in Coal Measures, with some remarks on filtration. *Trans. Manch. Geol. Soc.*, vol. xviii., pp. 61-68.

Fox-Strangways, C. Particulars of a Well Boring at Irton, near Scarborough, *Rep. Brit. Ass.* for 1883, p. 151.

—————— Explanation of Quarter Sheet 93, N.E. The Geology of the county N.E. of York, and S. of Malton. *Memoirs Geol. Survey.*

Gardner, J. S. British Cretaceous Nuculidæ. *Quart. Jour. Geol. Soc.*, vol. xl., p. 120., three plates. *(Speeton Clay).*

Geological Survey of England and Wales. Sheet 131. Horizontal sections of Yorkshire Coast from Redcar to Upleatham.

Hemingway, W. Fossil Flora of the Barnsley district. *Quart. Trans.* Barnsley Nat. Soc., vol. iv., p. 6, plate.

Jones, T. R., Kirkby, J. W. and Brady, G. S. Monograph of the British Fossil Bivalved Entomostraca from the Carboniferous formation. Part i., The Cypridinadæ and their allies. *Palæontog. Soc.*, 1884, pp. 57-92, plates.

Jukes-Brown, A. J. Student's Handbook of Physical Geology. 8vo. *London. (References to Yorkshire.)*

Oswald, S. On a perched block of Sandstone in Lunesdale. *Nat. Hist. Trans. N. D. and Newcastle*, vol. viii., pp. 181-184.

Phillips, J. Arthur. A Treatise on Ore Deposits, 8*vo. London*, pp. 651. *(Reference to Yorkshire.)*

Reid, Clements. Dust and Soils. *Geol. Mag.*, April, pp. 165-169. *(Reference to Yorksh. Wolds.)*

Teall, J. J. H. Petrological notes on some North of England Dykes. *Quart. Journ. Geol. Soc.*, vol. xl., pp. 209-247, pl. xii. and xiii. *Geol. Mag.*, n.s., dec. iii., vol. i., p. 92.

Tiffen, J. H. Prize Essay on the Agriculture of East and North-Riding of Yorkshire. *North British Agriculturist*, vol. xxxvi., pp. 773-738.

Wild, G. Sigillaria (Pot-holes) and their detection in the roof of a Coal Seam by their stigmarian roots. *Trans. Manch. Geol. Soc.*, vol. xvii., pp. 215-224, three plates. (Reference to Yorkshire.)

Williamson, Prof. W. C. On some supposed fossil algæ from Carboniferous rocks. *Rep. Brit. Assoc.* 1883, p. 493.

—————— Presidential Address to the Geological Section of the British Association at Southport. *Rep. Brit. Assoc.*, 1883, pp. 475-489. (Refers to Yorksh. Coal Plants.)

WOODWARD, Dr. HENRY. A monograph of British Carboniferous Trilobites. *Palæon. Soc.*, pt. ii., pp. 39-86, pl. vii-x.

WOODWARD, HORACE B. Synopsis of the Genera and species of Carboniferous Limestone Trilobites. *Geol. Mag.*, *n.s.*, dec. iii., vol. i., pp. 484-489.

WRIGHT, THOS. Monograph of Lias Ammonites of the British Islands. *Pal. Soc.*, 1884, pp. 441-480, pl. lxxviii.-lxxxvii.

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CARTER, RICHARD. "On the Mineral Wells at Harrogate." *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 313-319.

DAVIS, JAMES W. On a new species of Heterolepidotus from the Lias. *Proc. Yorksh. Geol. and Polyt. Soc.*, *n.s*, vol. viii., pp. 403-407, pl. xxii.

——— Summary of Geological Literature relating to Yorkshire. Published during 1884, with Addenda for 1880-1883. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 415-416.

DAVIS, R. H. The Mineral Wealth of Harrogate. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 357-366, woodcuts.

ETHERIDGE, R., Phillip's Manual of Geology. Part ii., 8*vo*. *London*, pp. xxiv., 712. *(Reference to Yorkshire.)*

FOX-STRANGWAYS, C. The Harrogate Wells; or, the Mineral Waters of Harrogate Geologially considered. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 319-335. Map.

GARFORTH, W. E. On the Fire-damp Detector; with recent improvements in the Miners Safety Lamp; and some remarks on the difficulties connected with Deep Mining. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 395-403.

HICK, T., and CASH, W. Contributions to the Fossil Flora of Halifax. Part iv., *Proc. Yorksh. Geol. Soc.*, *n.s.*, pp. 370-377, pl. xix.

HUDDLESTON, W. H. Contributions to the Palæontology of the Yorkshire Oolites. *Geol. Mag.*, n.s., dec. iii., vol. ii., pp. 49, 121, 151, 201, 252.

JUKES-BROWN, A. J. The Boulder-Clays of Lincolnshire, their Geographical, range and relative age. *Quart. Journ. Geol. Soc.*, vol. xli., pp. 114-132 (Comparison with Yorkshire series, p. 131), *Geol. Mag.*, n.s., dec. iii., vol. ii., p. 135.

OLIVER, Dr. GEO The Mineral Springs of the great anticlinal of the West-Riding: a few Chemico-Geological notes. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 336-356, pl. xvi.-xviii.

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SIMPSON, MARTIN. The Fossils of the Yorkshire Lias described from nature. 2nd. Ed., Whitby.

STOCKS, H. B. On the Composition of the Coal Balls and Baum Pots in the Lower Coal Measures. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 393-395.

VINE, G. R. Further notes on new species, and other Yorkshire Carboniferous Fossil Polyzoa described by Prof. Jno. Phillips. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 377-393., pl. xx.-xxi.

WHITELEY, R. L. Analysis of the Kissingen Saline Chalybeate Water, 1883, as compared with anaylses in 1845, 1854, 1867 and 1879. *Proc. Yorksh. Geol. Soc. n.s.*, vol. viii., pp. 366-370.

WILLIAMSON, Prof. W. C. "Biographical notice of John Williamson." *Proc. Yorksh. Geol. & Polyt. Soc.*, *n.s.*, vol. viii., pp. 295-313.

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Life members who have compounded for their annual subscriptions are indicated by an asterisk (*)

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*** It is requested that Members changing their residence, will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1885.

Computed from daily observations made at the Exchange, Bradford,

By John McLandsborough, F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, Assoc. M. Inst. C.E., F.R.Met.Soc., F.G.S.

Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Months	Pressure: Highest Reading of Barometer	Date	Mean of Highest of 17 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 17 Years	Range	Corrected for Capillarity and Temperature: Mean	Mean of 17 Years
	Ins	On	Ins	Ins	On	Ins	Ins	Ins	Ins
January	[illegible]	[illegible]	[illegible]	[illegible]	11th	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	[illegible]	2nd	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	11th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	10th	[illegible]	[illegible]	[illegible]	[illegible]	1.65	[illegible]	29.473
May	[illegible]	12th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June	[illegible]	10th	[illegible]	[illegible]	[illegible]	[illegible]	1.113	29.121	[illegible]
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	2nd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29.190
October	[illegible]	[illegible]	[illegible]	[illegible]	26th	28.214	[illegible]	[illegible]	[illegible]
November	[illegible]	16th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
December	[illegible]	23rd	[illegible]	29.129	4th	28.704	1.209	29.745	29.177
Means or totals	30.011		30.065	[illegible]		28.883	1.145	29.517	29.498

Months	Temperature of Air in Shade: Highest	Date	Mean of Highest of 17 Years	Lowest	Date	Mean of Lowest of 17 Years	Range	Mean in each Month: Of all Highest	Mean of 17 Years	Of all Lowest	Mean of 17 Years	Daily Range: Mean	Mean of 17 Years	Of Dry Bulb: Mean
	Deg	On	Deg	Deg	On	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	63.5	6th	53.6	25.0	22nd	23.8	28.8	[illegible]	43.1	34.1	34.5	7.8	8.7	37.4
February	56.0	25th	64.0	24.0	21st	26.9	34.0	47.5	[illegible]	[illegible]	35.8	11.1	9.0	41.5
March	61.3	21st	66.8	[illegible]	19th	[illegible]	[illegible]	47.3	47.0	[illegible]	35.6	11.4	11.4	39.1
April	65.5	20th	[illegible]	[illegible]	4th	41.1	37.2	51.7	[illegible]	38.6	39.8	13.1	13.5	[illegible]
May	[illegible]	29th	[illegible]	[illegible]	12th	34.7	36.5	51.8	58.5	[illegible]	41.6	14.1	14.9	46
June	[illegible]	6th	77.4	40.9	27th	41.8	39.7	65.1	65.2	49.0	[illegible]	16.3	15.2	55.1
July	[illegible]	[illegible]	[illegible]	44.8	[illegible]	46.9	37.4	69.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59.4
August	71.0	17th	[illegible]	42.0	14th	45.9	29.0	62.2	[illegible]	49.6	53.2	12.6	14.4	[illegible]
September	[illegible]	16th	[illegible]	[illegible]	28th	40.2	35.0	60.0	62.2	40.6	[illegible]	13.4	12	[illegible]
October	57.9	1st	[illegible]	[illegible]	30th	32.7	[illegible]	50.2	[illegible]	40.7	43.3	9.5	10.7	44.9
November	[illegible]	4th	[illegible]	[illegible]	[illegible]	28.2	31.2	46.3	47.2	38.4	38.0	7.9	9.1	[illegible]
December	48.8	18th	53.0	[illegible]	11th	23.2	26.7	43.4	42.7	34.3	34.3	9.1	8.4	39.6
Means or totals	[illegible]		64.9	[illegible]		33.5	31.6	53.1	51.5	41.2	42.6	11.9	11.9	46.5

Months	Dry Bulb: Mean of 17 Years	Adjusted Mean Temperature: Of Air: Mean	Mean of 17 Years	Of Evaporation: Mean	Mean of 17 Years	Dew Point: Mean	Mean of 17 Years	Vapour: Elastic Force: Mean	Mean of 17 Years	In a Cubic Foot of Air: Mean	Mean of 17 Years	Short of Saturation	Mean of 17 Years	Mean Weight of a Cubic Foot of Air	Mean of 17 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Ins	Ins	Grs	Grs	Grs	Grs	Grs	Grs
January	39.4	37.1	38.9	35.6	37.2	33.6	[illegible]	[illegible]	205	[illegible]	2.4	0.4	0.4	650	549
February	40.3	41.5	40.1	39.6	[illegible]	37.7	36.1	226	214	2.6	2.5	0.4	0.4	540	[illegible]
March	[illegible]	38.8	40.5	36.2	[illegible]	[illegible]	[illegible]	[illegible]	206	2.2	[illegible]	0.6	0.5	[illegible]	647
April	45.2	44.3	45.2	40.7	41.8	36.5	[illegible]	[illegible]	231	2.5	2.7	0.8	0.8	540	[illegible]
May	49.4	46.0	49.3	42.4	[illegible]	[illegible]	40.9	[illegible]	257	2.7	2.9	0.9	1	[illegible]	[illegible]
June	55.7	55.2	55.7	50.2	51.2	45.4	[illegible]	[illegible]	321	3.4	[illegible]	1.5	1.4	533	531
July	60.4	59.2	60.2	53.9	54.6	[illegible]	[illegible]	350	368	4.0	4.1	1.7	1.7	[illegible]	526
August	59.1	54.6	[illegible]	50.2	54.2	46.0	50.5	310	[illegible]	3.5	4.1	1.3	1.5	[illegible]	520
September	54.6	52.5	54.7	48.8	51.4	45.0	48.1	[illegible]	[illegible]	3.4	3.8	1.0	1.0	532	531
October	48.3	[illegible]	[illegible]	[illegible]	45.6	[illegible]	42.8	[illegible]	276	2.7	3.2	[illegible]	[illegible]	538	[illegible]
November	42.6	42.1	42.2	40.4	46.0	38.3	[illegible]	[illegible]	222	2.7	2.6	0.4	0.5	544	544
December	39.2	39.2	38.8	37.6	[illegible]	[illegible]	34.4	208	200	2.4	2.3	0.4	0.4	552	648
Means or totals	47.9	46.3	47.7	43.2	44.5	39.8	41.2	250	267	2.9	[illegible]	0.8	0.9	540	539

Months	Degree of Humidity (Complete Saturation = 100): Highest	Date	Mean of Highest of 17 Years	Lowest	Date	Mean of Lowest of 17 Years	Mean	Mean of 17 Years	Temperature of Air in Sun's Rays: Highest	Date	Mean of Highest of 17 Years	Mean	Mean of 17 Years	Wind Direction (Relative Proportion at 9 a.m.): N	NE	E	SE	S	SW	W	NW
	0–100	On	0–100	0–100	On	0–100	0–100	0–100	Deg	On	Deg	Deg	Deg	No	No	No	No	No	No	No	No
January	[illegible]	23rd	97	74	8th	[illegible]	87	86	65.0	30th	60.2	41.8	47.8	2	4	5	8	5	6	0	1
February	99	2nd	[illegible]	55	24th	[illegible]	[illegible]	86	67.6	25th	72.1	62.5	62.8	2	2	1	3	[illegible]	10	5	[illegible]
March	98	4th	96	50	27th	[illegible]	80	[illegible]	72.2	23rd	84.1	58.1	62.0	6	7	1	1	1	[illegible]	2	7
April	97	[illegible]	[illegible]	41	[illegible]	64	74	78	88.2	20th	96.2	64.6	73.4	3	6	5	4	4	3	3	2
May	93	1st	[illegible]	43	27th	[illegible]	75	73	85.0	29th	105.6	75.1	61.5	3	4	1	1	2	5	6	[illegible]
June	99	14th	93	32	4th	49	70	72	116.4	11th	111.9	86.8	67.5	6	3	0	4	1	8	5	3
July	87	27th	91	44	14th	[illegible]	[illegible]	70	113.6	27th	114.3	92.1	92.1	1	5	1	3	1	9	4	4
August	91	6th	92	48	14th	52	73	[illegible]	98.2	17th	111.6	81.7	[illegible]	11	5	3	2	[illegible]	4	3	1
September	99	18th	[illegible]	[illegible]	15th	[illegible]	77	79	91.6	6th	100.0	81.1	80.6	4	1	1	0	2	[illegible]	[illegible]	5
October	97	[illegible]	[illegible]	59	12th	62	81	[illegible]	79.2	5th	66.4	65.1	66.7	7	6	2	2	0	7	3	5
November	100	17th	[illegible]	65	4th	63	87	83	65.6	2nd	71.5	57.1	55.1	3	7	[illegible]	2	2	6	3	1
December	98	18th	93	72	4th	68	87	85	59.2	1st	67.3	50.4	46.6	0	2	1	2	1	5	7	[illegible]
Means or totals	97		95	52		58	79	79	81.8		89.4	67.2	69.7	[illegible]	51	28	35	26	78	47	39

Months	Wind Pressure: Mean of all	Mean of all Highest	Highest	Direction	Date	Mean Amount of Cloud	Number of Days Rain fell	Rain: Amount Collected	Greatest Daily Fall	Date	Mean of 16 Years	Gauges at Town Hall & Mid. Stn. (mean)	[illegible]	Depth in Inches	Percentage of fall at Exchange
	lbs per sq. ft	lbs per sq. ft	lbs per sq. ft		On	0–10	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	0.6	2.91	[illegible]	W S W	11th	[illegible]	[illegible]	[illegible]	0.41	11th	2.70	2.209	2.474	[illegible]	11.2
February	1.1	[illegible]	[illegible]	W	11th	7.9	26	[illegible]	[illegible]	[illegible]	2.11	[illegible]	[illegible]	[illegible]	11.4
March	[illegible]	[illegible]	1.50	W	21st	7.6	14	[illegible]	[illegible]	4th	2.11	[illegible]	[illegible]	0.484	11.7
April	0.7	[illegible]	[illegible]	S W	1st	7.2	13	[illegible]	0.73	7th	[illegible]	[illegible]	[illegible]	[illegible]	11.2
May	0.9	[illegible]	[illegible]	W	11th	7.2	21	[illegible]	[illegible]	5th	1.64	[illegible]	[illegible]	[illegible]	10.8
June	0.6	[illegible]	[illegible]	S W	[illegible]	[illegible]	12	[illegible]	[illegible]	24th	[illegible]	[illegible]	[illegible]	0.174	[illegible]
July	0.4	[illegible]	[illegible]	S W	[illegible]	6.6	7	[illegible]	0.41	[illegible]	2.9	[illegible]	[illegible]	0.240	10.7
August	[illegible]	2.55	[illegible]	S S W	[illegible]	7.2	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	[illegible]	11.5	S S W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.2
October	1.0	4.02	[illegible]	S W	[illegible]	7.2	21	5.13	[illegible]	[illegible]	[illegible]	3.640	[illegible]	0.372	11.0
November	0.7	[illegible]	12.60	W S W	28th	8.0	17	2.29	0.53	27th	2.92	3.421	3.828	[illegible]	11.2
December	0.9	[illegible]	15.25	S W	4th	8.3	10	[illegible]	0.13	5th	2.73	3.681	4.170	[illegible]	11.1
Means or totals	0.8	3.02	9.98			7.3	[illegible]	25.70	0.54		31.31	35.741	39.601	3.860	11.08

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, and Humidity from 1869 to 1885, and Rainfall from 1870 to 1885, inclusive.

Year	Pressure: Highest: Reading of Barom. during Year	Date	Lowest: Reading of Barom. during Year	Date	Temperature in Shade: Highest: Reading of Maximum Thermom. during Yr	Date	Lowest: Reading of Minimum Thermom. during Yr	Date	Last and First Frost of Season: Date of Last Frost	Date of First Frost	In Sun's Rays Highest: Reading of Solar Thermom. during Yr	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Yr	Date	Lowest: Degree of Humidity during Yr	Date
	Ins		Ins		Deg		Deg				Deg		0–100		0–100	
1869	30.290	Dec 6	28.500	Feb 1	85.2	Aug 30	19.8	Dec 23	Mar 27	Oct 20	127.7	Aug 30	[illegible]	Feb 8	42	Sep 24
1870	30.254	Jan 19	28.308	Jan 8	85.0	July 25	16.6	Dec 23	Mar 30	Nov 9	127.5	July 25	[illegible]	Jan 29	40	July 14
1871	30.152	Mar 26	28.308	Jan 16	84.0	Aug 12	6.7	Jan 1	April 11	Nov 13	128.7	July 17	[illegible]	July 7	43	Nov 2
1872	30.156	April 6	28.070	Jan 24	[illegible]	July 23	24.6	Mar 27	Mar 27	Nov 19	124.8	Aug 19	100	Mar 22	45	Sep 23
1873	30.338	Feb 18	28.022	Jan 20	[illegible]	July 23	19.2	Feb 24	Mar 14	Nov 5	124.5	July 23	100	Dec 11	41	Mar 26
1874	30.476	Mar 6	28.276	Dec 11	80.9	July 20	16.0	Dec 31	Mar 12	Nov 11	125.8	July 20	100	Feb 6	42	May 18
1875	30.305	July 7	28.484	Nov 10	80.0	Aug 17	13.6	Jan 1	Mar 22	Nov 26	122.0	July 5	100	Jan 23	43	June 6
1876	30.360	Jan 15	28.070	Dec 4	87.6	July 17	23.0	Jan 9	April 16	Nov 9	125.6	July 16	[illegible]	Oct 4	46	May 6
1877	30.378	Oct 6	[illegible]	Nov 29	80.0	June 19	20.0	Mar 1	May 4	Oct 18	116.4	June 19	100	Oct 29	35	May 23
1878	30.320	Mar 16	28.630	April 1	69.6	July 19	13.9	Dec 26	April 6	Nov 9	118.2	July 22	[illegible]	Jan 13	53	Aug 9
1879	30.352	Dec 13	28.560	Feb 10	74.4	July 30	13.2	Dec 7	May 10	Nov 14	101.2	Aug 13	100	Oct 7	51	Dec 19
1880	30.332	Jan 7	28.154	Nov 16	81.3	Sep 5	20.8	Jan 20	Feb 23	Oct 20	112.0	Aug 13	[illegible]	Dec 15	50	May 30
1881	30.362	May 10	28.260	Oct 14	83.3	July 6	12.0	Jan 26	April 21	Oct 17	116.5	June 1	91	Oct 14	38	May 31
1882	30.544	Jan 18	28.452	Mar 1	77.4	Aug 12	18.6	Dec 11	April 16	Nov 12	108.0	Aug 9	91	Nov 5	36	May 18
1883	30.500	April 9	28.452	Sep 2	78.2	July 3	19.8	Mar 10	Mar 29	Nov 12	107.6	May 17	91	Dec 26	30	April 9
1884	30.364	Oct 5	28.376	Jan 27	84.4	Aug 12	26.6	Nov 30	April 24	Nov 24	107.8	Aug 9	98	Jan 23	30	May 22
1885	**30.273**	**Mar. 14**	**28.400**	**Jan. 11**	**82.2**	**July 27**	**22.1**	**Dec. 11**	**April 5**	**Nov. 18**	**113.6**	**July 27**	**100**	**Jan. 23**	**32**	**June 4**
Means	**30.336**		**28.327**		**82.7**		**17.9**				**118.1**		**99**		**41**	

Year	Rain: Total for Year	Mean Yearly Rainfall at Town Hall & Midland Station	Gauges at Town Hall & Mid. Stn.: Depth in Inches	Percentage of fall at Exchange	Greatest Daily Fall	Date	Snow: Date of Last Snow	Date of First Snow
	Ins	Ins	Ins	Per cent	Ins			
1869					[illegible]	June 18	April 1	Oct 19
1870	24.190				[illegible]	June 16	Mar 24	Nov 15
1871	31.440				2.450	June 19	Mar 15	Nov 16
1872	42.060				[illegible]	Jan 19	Mar 11	Nov [illegible]
1873	[illegible]				1.300	Aug 4	April 25	Jan 4, '74
1874	24.550				0.740	Dec 7	May 9	Nov 26
1875	30.28[illegible]				1.700	Nov 15	Mar 12	Nov 9
1876	35.270	39.[illegible]	4.518	11.28	1.310	Oct 1	April 12	Nov [illegible]
1877	40.450	45.490	[illegible]	11.13	1.420	July 16	May 19	Oct 15
1878	35.444	[illegible]	[illegible]	[illegible]	1.220	Aug 14	April 1	Nov 19
1879	29.017	[illegible]	2.281	[illegible]	1.120	June 8	May 7	Nov 20
1880	35.690	[illegible]	3.526	[illegible]	1.710	Oct 27	Mar 2	Oct 27
1881	35.434	[illegible]	4.458	11.26	1.435	Oct 15	April 20	Oct 29
1882	[illegible]	43.103	3.420	10.86	1.608	Dec 6	Mar 21	Nov 10
1883	34.496				1.318	Sep 26	Mar 21	Nov 10
1884	27.057				1.170	Jan 19	Feb 28	Nov 23
1885	**25.699**	.....	.....	.....	**1.208**	**Sep. 3**	**May 7**	**Dec 9**
Means	**31.314**	**39.601**	**3.880**	**11.08**	**1.387**			

EXPLANATION.

The observations are made at [illegible] a.m. [illegible], with the exception of maximum and minimum thermometers [illegible].

The highest and lowest readings of barometer for each month, also the monthly range, are given as recorded, while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level the mean temperature being 48 degrees and barometer reading 30 inches at sea level, add .401 inch to the heights given.

The adjusted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings, the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from [illegible] readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The solar thermometer has a black bulb enclosed in vacuum.

The direction and pressure of wind are recorded by [illegible] attached to an Anemometer fixed 10½ feet above the ridge of roof of Exchange. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65 feet above the surface of the ground, and 377 feet above mean sea level. As rain gauges on the roofs of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1876 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of different open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situated about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of [illegible] the ground they occupied being too much [illegible] the [illegible]. The particulars of these gauges are set forth in tables. The result shows that the mean yearly rainfall at the surface of ground for the seven years ending with 1882 is [illegible] inches, or [illegible] per cent. greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the sixteen years ending with 1885 is 31.31 inches. By adding 11.08 per cent. thereto the mean annual rainfall of central Bradford for such period is found to be 34.78 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind, these producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of a central roof, the place it has since occupied. To avoid risk of inaccurate results the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

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WITH SEVEN PLATES.

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1886.

ON SOME REMARKABLE PROPERTIES OF THE CHARACTERISTIC CONSTITUENT OF STEEL, BY H. C. SORBY, ESQ., LL.D., F.R.S.

The microscopical examination of suitably prepared specimens of iron and steel with moderately high magnifying powers shows that there are two very well marked constituents. One of these is comparatively soft, and is undoubtedly iron free from carbon. The other is intensely hard, and most probably contains combined carbon, since it occurs in white cast iron, blister steel and other varieties known to contain carbon in that state. Independant of these there is obviously another constituent which has microscopical characters entirely unlike those of the others, and gives beautiful colours like mother of pearl. For this reason I have always called it the pearly constituent. Laterly I have made use of very much higher magnifying powers, and find that with an illuminator contrived some years ago by the late Richard Beck, a power of 650 linear can be employed with ease. This shows that the pearly constituent really has a structure closely like that of pearl, being made up of alternating thin plates. After very carefully studying most of the leading varieties of iron and steel, I have come to the conclusion that these plates are alternating layers of soft iron free from carbon, and of the intensely hard compound with carbon, already mentioned. The

laminæ are often of extreme thinness, those of the soft iron being often about $\frac{1}{40000}$th inch in thickness, and those of the hard substance only $\frac{1}{80000}$th, so that we have alternating ridges and grooves about $\frac{1}{60000}$th inch apart. The only satisfactory explanation for this remarkable structure appears to be that at a high temperature a stable compound of iron and carbon exists, which is not stable at a lower temperature, but breaks up with the two substances named above, which certainly are stable at both a high and low temperature.

What we see in examining an ingot of cast steel of medium temper is that comparatively large crystals are formed on solidification. As the temperature becomes somewhat lower these break up into smaller crystals; and finally these resolve themselves into the extremely thin alternating plates, the direction of which is probably determined by the previous crystalline structure. So far as I am aware no strictly parallel case is known to occur in any other substance, but at the same time it must be admitted that it has not been specially looked for with very high power, and might well enough occur under such circumstances that it could not be recognized even if present.

Independent of the interest that may be attached to such a remarkable structure, it seems to me that the facts throw much light on the hardening and tempering of steel. It is possible and indeed probable that when red hot steel is suddenly cooled by plunging it into cold water, the compound of iron and carbon which is stable at a high temperature is suddenly fixed, before it has, so to speak, time to break up, and retains properties intermediate between those of the soft iron and the intensely hard but brittle compound, that is to say, combines great hardness with strength. On again raising the temperature somewhat, so as to temper the hardened steel, we can easily understand that the two constituents separate out to a greater or less extent, so as to give rise to a structure like that met with when the steel is slowly cooled. As far as I can learn, this view of the subject agrees perfectly well with all the facts seen by studying different kinds of iron and steel with high magnifying powers.

ON EXPLOSIVES USED IN MINING. BY JOSEPH MITCHELL, ESQ.

I intended to have read a paper upon the present extension of the Silkstone Coalfield, but I am prevented doing so because the explorations are in the hands of gentlemen who are anxious for the present to keep them private; however I may mention that so far as the extension of the Silkstone Coalfield in South Yorkshire is concerned, that it is progressing, and that the coal which has been reached in the new workings in the Dearne Valley District is of even better quality than that on the rise side of the Main Worsbro' Fault. We may, therefore, look forward to the developement of the various coal measures underlying the Barnsley Seam, and rest satisfied that the Coalfield of South Yorkshire will be extended for many years to come, and, I hope, will be a source of profit to everybody concerned.

With regard to the Final Report on the Royal Commission on Accidents in Mines, I am pleased to see that it has completed its enquiries, and that practically the conclusions to which the Commission has come in many instances are similar to what the Midland Institute and other Societies in connection with Mining in Great Britain found to be the proper methods to be adopted to ensure increased safety in the working of mines, and had been recommended by these Societies to the Royal Commission, although such recommendations do not appear to be properly acknowledged in the Report itself; therefore we may consider that these various Societies have done something to enable the Royal Commission to come to a proper conclusion in their Report.

The Report particularly deals with the Lighting of Mines.

Various experiments had been conducted during the past year by several of the Societies and Mining Institutes, as well as the Royal Commission, and I am happy to say that the conclusion arrived at by the Institute which has its centre in Barnsley (The Midland Institute of Mining, Civil and Mechanical Engineers) was practically in accordance with that of the Royal Commission, which was that a good light

should be provided for the workmen, so that they may be able to protect themselves from injuries from falls of roof and sides and other accidents of a similar nature, but the light must be at the same time so protected that it may be able to withstand an explosive atmosphere at a great velocity and to be self-extinguishing.

The conclusion that the Midland Institute came to was, that a lamp of the Mueseler type, fitted with a "bonnet", was the most suitable. This type of lamp was tested under the direction of a Committee especially appointed for the purpose at Aldwarke, and their conclusion was that gas could not be ignited outside this lamp at any velocity up to 3000 feet per minute, which was the maximum velocity attained.

As no current in a mine in its ordinary course travelled at any such speed as 3000 feet per minute, it was clear they had arrived at something like a fair and proper safety lamp for the protection of the workmen, as against previous safety lamps.

The next question to be considered was, how to test the lamp prior its being sent into the mine? Some difficulty had arisen and some speculation as to the real safety of sending a lamp in without being properly tested, and several ingenious ways of testing had been suggested and tried, but I do not know of any so simple and practical as one that I have adopted at Mitchell Main Colliery, which is to place the lamp in a current of such a velocity as to exceed that of any current of air in the mine. This is done by means of an apparatus consisting of a long wooden tube with glass sides, and the current is created by a steam jet. In the apparatus several lamps can be tested at the same time.

The reason I have adopted this system of testing is because in the various tests we found that if the flame was affected to such an extent as to cause the light to flicker, we were able to explode it, but if the light of the lamp remained quiescent in a current of from 23 to 26 feet per second it was safe for all ordinary purposes. The apparatus is very simple, and worthy the consideration of all colliery managers.

The next thing the Committee dealt with was a very important one, viz.:—that of firing shots in mines. They had practically con-

demned the use of powder, because there was a tendency to a flame, and, of course, a flame in mines where there was any chance of gas being given off, was a very dangerous element. After a very long and deliberate examination of the whole question, the Commission came to the conclusion that a quick explosive was the most desirable, and the explosive recommended was gelatine dynamite.

I have the pleasure to exhibit to you the best explosive cartridges at present known, and the various cases in which the cartridges are fixed inside and surrounded by water, also the electric fuse with detonater attached, and the battery and appliance for firing the shots.

The effect of the firing of the explosive is instantaneous and gives off no flame. It has been said to give off a few sparks when fired without the protecting water cartridge, but when used in conjunction with the water cartridge case there is no flame given off, and consequently no risk of igniting inflamable gas. It is, therefore, a satisfactory substitute for gunpowder.

ON A CONCRETION CALLED ACRESPIRE. BY H. B. STOCKS, ESQ.

In the millstone grit formation curious concretions occur, which are known locally by the name of acrespire. These concretions are found in the bed which produces the most useful stone, and entirely spoil the stone where they occur, rendering it unfit either for building or paving purposes. The acrespire itself, from its hardness and other properties, can only be used as road metal.

Acrespires are generally very hard and close grained, and are sometimes covered by a coating of friable brown sand. The general colour is grey, sometimes brown, bluish-white, and white. In size they vary from a few inches to many feet. They are of various forms, the most general being oval and oblong; sometimes nearly square blocks occur.

Planes of stratification have been noticed in one specimen. but in all the others examined no such planes were observed.

Specimens from two localities near Halifax were analysed, with the results given below:—

		Ringby.	Lightcliffe.
Soluble in HCl.	Ferric Oxide	4·12.	——
	Ferrous Oxide	——	2·17
	Manganous Oxide	——	trace.
	Alumina...	0·92.	0·43.
	Lime	19·37.	20·53.
	Magnesia	——	trace.
	Carbonic Acid	12·13.	16·31.
	Silica	0·16.	0·52.
	Phosphoric Acid	trace.	——
	Silica insoluble in HCl. (sand)	60·90	58·23.
	Moisture	0·92.	0·25.
	Alkalies and loss	1·48.	1·56.
		100·00.	100·00.

The above figures show how well the two specimens agree in composition.

I append an analysis of a white sandstone, also from Halifax, to show in what points the acrespires differ from the sandstone.

Silica (soluble)	3·10.
Silica (insoluble)	89·23.
Alumina	1·34.
Ferric Oxide	2·72.
Lime	0·10.
Alkalies	1·17.
Loss on ignition. (Water and Organic Matter) ..	1·55.
	99·21.

On comparing the three analyses together, we see that the essential difference is, that the acrespire contains about 31 or 32 per cent. of carbonate of lime, which has been introduced into its formation.

ON THE MICROSCOPICAL STRUCTURE OF ROCKS. BY THE REV. J. MAGENS MELLO, M.A., F.G.S., ETC.

Whilst Geology was still in its infancy, more attention was paid to the broader or more general features of the earth's structure and past history, than to the minuter details of its component parts. The arrangement of the rocks forming that portion of its crust accessible to man, their organic contents as affording a key to their relative Chronology, the physical causes producing the various changes that are seen to have taken place in connection with these rocks and their enclosed fossils, the chemical composition of the different minerals, these were amongst the principal objects set before the Geological student, and are those which still largely engage his attention; but of late years we have been taught to see that would we thoroughly comprehend the history of the rocks of our globe, we must not only study them on a large scale, not only analyse them in the chemical laboratory, but we must not rest satisfied until we have searched into their innermost structure, and have learned to unravel by means of the microscope and the polariscope the wondrous history of their formation, and of the varied changes that they have passed through during the lapse of ages.

There are many questions which cannot be answered by the unaided eye. We can, indeed, by the eye alone learn to distinguish between most of the ordinarily met with igneous and aqueous rocks. A mere tyro in geology sees at a glance the difference between grits, sandstones, limestones, shales or slates, and can discriminate between them and the commoner igneous rocks, such as granites, dolerites, etc. The crystalline or vitreous texture of the igneous rocks will in most cases afford a sufficient indication to enable them to be recognized by the eye alone; but the eye can tell us nothing without instrumental aid as to the minute structure of such rocks, nor can it read the history of their origin, and of the subsequent changes they may have experienced: neither can it, without the microscope,

detect the differences existing between similar-looking rocks from different localities, or belonging to different periods. Again, with regard to the organic remains in rocks, whilst we can readily see the larger fossils, there are myriads of smaller ones which require the microscope for their detection. Some of the Eocene Limestones, for instance, consist of little besides minute foraminifera, as many as 58,000 of them, it is said, are contained in every cubic inch; the Silurian and Carboniferous, as well as other limestones, when microscopically examined, are found to contain myriads upon myriads of organisms too small to be seen by the naked eye.

There are other rocks, such as the Tripoli and semi-opal of Bilin, in Bohemia, which are almost entirely composed of diatomaceæ, and spicules of silicious sponges. Such spicules, together with foraminifera, not only form the bulk of chalk, but also crowd the nodules of flint so common in that formation. Diatomaceæ also enter largely into the composition of bog iron ore In the examination of the larger fossils the microscope is often of great use in working out details of structure. We know too, how much has been done by its means in determining the structure of fossil plants: for instance, in proving the vegetable origin of coal, many varieties of which are found to be entirely built up of minute parts of plants. It is however more in connection with the mineral history of the rocks that the vast importance of microscopical examination will be seen.

Chemistry can tell us the elements of which any given mineral is composed, and the proportions in which those elements exist in it. So can that science also tell us the composition of any rock; but in the case of the rock, all that chemistry can do is to say what elements enter into its formation, and the quantities in which these occur; unless the separate minerals of which the rock is built up can be clearly seen, it cannot tell us *how* they are distributed in it. Nor can the chemist give us any decided clue as to the origin of the rock in question, save that he can sometimes gather from the presence of carbonate of lime, or carbon and other elements, that organic life had probably some part in the formation of the rocks in which these are found. But neither chemistry nor the unaided sight can discover what part igneous or aqueous actions have played in the history of a

rock. Whether it is a purely aqueous deposit, or the result of igneous fusion, whether it has been crystallized from watery solution or after gaseous sublimation, or out of simply molten materials; or whether all these agencies, igneous fluidity, sublimation and heated water have at once or successively taken part in its formation. These are the questions to which we are beginning to receive answers from the use of the microscope, and the value of this instrument in geological investigations is daily becoming more and more recognized, so much so, indeed, that no description of a rock can be considered complete, without some record of its microscopical structure.

For the purposes of examination, we may consider the rocks as divided into two great classes Aqueous and Igneous, there are others of more or less doubtful character, rocks which may indeed belong to either of the above classes, but which have undergone alterations subsequent to their original formation.

Professor Bonney noting an objection raised to sharp lines of demarcation, says that "it is impossible to draw a hard and fast line "between igneous and sedimentary rocks, because the former are "frequently only the result of metamorphosis of the latter carried to "an extreme degree, so that the one series passes gradually into the "other" at the same time points out that, for all practical purposes, this need not be any real difficulty, the majority of rocks can be grouped around certain types, and there is also a marked difference as a rule between the rocks classed as igneous and the sedimentary, a difference not merely in appearance and structure, but also what is more important, in chemical composition. By an igneous rock we mean one "that has solidified from a state of fusion due to the "existence of an elevated temperature, whether we may call this dry "fusion or not."

The great mass of the aqueous rocks are those commonly known as the "stratified rocks", having been thrown down as sediments or precipitates, or elaborated by organic agency, and which occur in an orderly succession of beds, whilst the igneous rocks are more irregular in their mode of occurrence, they may underlie the stratified rocks, or they may pierce through them, forming dykes or veins, or on the other hand, they may be interbedded with some of them and

form overlying sheets of once molten lavas, or yet again as volcanic dust and ashes they may have spread over certain areas, ejected from subaerial vents. Now it has been already observed that the unaided eye cannot always distinguish between an aqueous and an igneous rock; there are some fine grained sedimentary rocks which to the eye might at first appear little different from others of igneous origin, and vice versâ; and even a chemical analysis will fail to show the difference, since many of the aqueous rocks have been directly formed by the disintegration of the igneous. But place a thin section or even a splinter of such a rock on the stage of your microscope, and the difficulty vanishes. The broken and often water-worn fragments of the aqueous rock, and occasionally traces of organic remains will at once reveal its nature, whilst, on the other hand, the peculiar characteristics of the igneous specimen will leave no doubt as to its origin.

Let us now begin our observations with the rocks of undoubted igneous character. It is with these that microscopic investigation has proved of the highest value, enabling us to determine not only the nature of the minerals which enter into their composition, even when very sparingly present; but also under what circumstances they were brought together, the relative amounts of heat and pressure to which they were subjected, and whether they were amongst the original constituents of the rock under examination, or were subsequently introduced.

How these questions are answered I shall endeavour to show, premising that before we can do anything, sections of the rock must in almost every instance be prepared, so as to allow of their investigation by transmitted light.

In examining a thin section of an igneous rock we shall see that it may be either a compound of more or less definitely formed crystals of various minerals, or it may be what is called a glass, being amorphous, but often containing included crystals, or grains of non-glassy material. In examining such a rock section, one of the first things that may strike us is that almost all its crystalline elements contain minute cavities, some of them filled with air or other gas, as carbonic acid, some with liquid, whilst others are filled up with solid mineral

matter. Many years ago, Dr. Sorby, F.R.S., published a very important paper "On the Microscopic Character of some Crystals", a paper which, more than anything else, gave the impetus to microscopic research in geology. In this Dr. Sorby showed that these cavities afford a clue to the history of the crystal in which they occur.

Before giving some of his principal results, it will be necessary to point out how these various kinds of cavities can be distinguished from each other. When a moderately high power, say $\frac{1}{4}$ inch, is brought to bear upon them, some of them will be found to contain a small moveable bubble, which will change its position as the slide is turned, or in some cases will be in constant motion; this cavity is a "fluid cavity", and when such a bubble is absent we may know a full fluid cavity from a gas cavity by the broad black outline of the latter, by transmitted light, and also by the fact that the latter will shine brilliantly when the light is reflected from its surface, a fluid cavity under reflected light being almost invisible, Glass cavities sometimes contain bubbles, but these are immovable, stone cavities are those which are filled with minute crystals.

It is of great importance in studying the history of a rock to pay close attention to the nature of the cavities found in its component crystals. The principal points, as deduced from Dr. Sorby's observations, may thus be tabulated:—crystals containing

Fluid cavities—were deposited from aqueous solution.

Glass or stone cavities—were deposited from igneous fusion.

Gas cavities—were formed by sublimation, or by the solidification of a fixed homogeneous substance, unless they are merely empty fluid cavities.

Fluid and gas cavities in a single specimen—were formed under the alternate pressure of the liquid and a gas.

Fluid and glass or stone cavities in a single specimen—were formed under great pressure by combined actions of igneous fusion and water.

Fluid and gas, and glass or stone cavities in a single specimen—show the action of gaseous sublimation, together with igneous fusion and aqueous solution under great pressure.

It may be added that the more numerous the cavities, the more rapidly was the crystal formed.

Having thus carefully noted the character of the cavities found in the specimen under inspection, we may next proceed to determine the nature of its component minerals, most of which can be readily known by their structural appearance as seen with the microscope, either by the use of natural or by polarized light.

Some minerals we shall at once recognize by their definite crystalline forms, which will be apparent even without using the polariscope. Thus sections of quartz crystals, the various specimens of felspar, augite and calcite may often be readily known by their characteristic shapes. Calcite, for instance, will be seen very clearly to be striated by fine lines, slightly iridescent, crossing each other and dividing the mineral into its primary rhomboidal crystals, the divisional planes of which are thus traced. But for minute investigation the polariscope is essential; without it it would be utterly impossible to distinguish indefinitely shaped crystalline masses; also such minerals as hornblende, biotite and other micas and augite, as well as numerous less common crystalline substances would be frequently confounded. Without the polariscope we should be unable to discriminate between the different species of felspar; we could not detect the difference between a crystalline and a glassy base, both would appear equally structureless. But directly the polariscope is used a new revelation is before us. Previously indefinite looking forms at once stand out in their true relationships, and the whole history of the rock under examination may be read, each separate crystal, or part of a crystal, is seen sharply contrasted with its neighbour, and its species can be readily determined, the brilliant colouring due to the polarization of the light serving to bring to view details of structure which without its use would be either invisible or meaningless.

In igneous rocks we have those that are glassy, such as obsidian, tachylite, etc., and crystalline rocks as granite and dolerite. How then to distinguish between a glassy rock and a crystalline rock, when the characteristic features are not plainly visible to the eye? A glass has no definite external form as has a crystal, nor is it of definite chemical character. In many rocks there is a glassy base enclosing crystals, whilst in others the base is crystalline, but the crystals are so small as to be invisible to the unaided sight. How is the glass to

be distinguished from the crystal? The polariscope at once helps us. When we place a glass between the crossed Nicholls we find it has no power to remove the darkness, but substitute for the glass, say a plate of selenite, and at once light is restored, coloured according to the thickness of the film. However much you may rotate your section you produce no change if the object before you is a glass, for it has no double refraction, but the great majority of crystals are possessed more or less of this property, they are what is termed anisotropic, those however which belong to the cubic system are isotropic, and do not polarize, the others are variously coloured according to circumstances, but are never absolutely dark between the crossed prisms, unless the section is one cut at right angles to the principal axis of the crystals belonging to the tetragonal or or hexagonal system, or at right angles to an optic axis in a bi-axial crystal, or again when an axis of elasticity coincides with the shorter diagonal of the polariscope, and then it is not absolutely dark as is glass, for on rotating the section light will pass through it.*

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* NOTE.—The following tables, taken from Mr. Rutley's text book on "The Study of Rocks", will be found useful for reference:—

When a section shows single refractive, *i.e.*, remains dark between crossed nicholls, it may be—

	1	Amorphous (glassy)—Singly refractive in all directions.		
Crystalline.	2	Cubic		" " "
	3	Uniaxial	Tetragonal Hexagonal	Singly refractive in the direction of the principal crystallographic axis.
	4	Biaxial	Rhombic Monoclinic Triclinic	Singly refractive in one or the other of the two optic axes, or when an axis of elasticity coincides with the short diagonal of polariser.

II.

1 A section showing colour between crossed prisms, giving four consecutive changes from darkness to colour, then when the principal directions of vibration are parallel and at right angles to the crystallographic axes the sections may be tetragonal, hexagonal, rhombic, or monoclinic.

2 If all the sections of the same mineral do not behave alike, the mineral is tetragonal, hexagonal, or monoclinic.

3 If besides sections which show colour under crossed prisms there are others of the same mineral appearing dark, and if the former show dichroism and pleochrism, it is tetragonal or hexagonal.

4 If besides the sections in which the principal directions of vibration are

Amongst minerals which may become dark between crossed Nicholls, when cut at right angles to an optic axis, is the mica so abundant in sections of granite, but rotation will at once show that the dark object before us is no glass, glass remaining under all changes of position colourless.

Such structural peculiarities as twin crystallization are clearly and beautifully defined by the use of the polariscope, the twinned crystals being distinguished by different and complementary colours, thus we have a ready mode of determining in many cases whether a felspar in the rock under examination belongs to the orthoclastic or plagioclastic series, the latter being very usually, though not invariably, divided into more or less numerous parallel twin crystals, which, as for instance in labradorite, give the crystal a very beautiful ribbon-like appearance, the stripes being usually exquisitely contrasted complementary tints. Orthoclase felspars, though often twinned on a larger scale, are not minutely twinned as are the triclinic varieties. There is one remarkable form of twin structure which is called lamellar. Crystals of leucite and of boracite exhibit lamellar polarization in a very perfect manner, the sections of these minerals are seen to be very definately striated, the striæ instead of being all parallel, as in the felspars, cross each other at a certain angle, having a kind of basket-work appearancc.

I have already alluded to the presence of minute crystals embedded in the substance of the larger ones, careful observation of of these, as of the base in which the larger crystals are found, will

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parallel and at right angles to the crystallographic axes (sections lying in the zone of the orthodiagonal) there are others in which this is not the case, the mineral is monoclinic.

5 When all the sections behave similarly and may be pleochroic, it is rhombic.

6 If the principal directions of vibration are neither parallel nor at right angles to the crystallographic axes and pleochroism occurs, we have a monoclinic or a triclinic mineral.

7 If all the sections do not behave alike and in some the principal directions of vibration are not parallel or at right angles to the crystallographic axes, the mineral is monoclinic.

8 If all the sections behave alike, it is triclinic.

enable us to determine which elements of the rock cooled down first, and will also show the direction of motion in its substance. Microlites, as these microscopic crystals are called, are extremely common in most of the basic rocks, as in dolerite, basalt, obsidian, and others, microlites of augite being very frequent. We also meet with microlites of hæmatite in felspar, magnetite too is continually present. Amongst other minute forms found in the igneous rocks are some with no definite crystalline structure. some of those which are termed crystallites are semi-crystals, or, as Mr. Teall says, "bodies intermediate between glass and true crystal." Then again we shall in some cases detect what is known as spherulitic structure, crystalline fibres radiating from a central point and which give rise to a dark interference cross which remains stationary as we rotate the object. Spherulitic structure is often found in the glassy rocks, and is a mark of devitrification, the gradual alteration of a glass into a more or less crystalline condition, and the existence of spherulites tend to show that the rock in which they are developed has at one period been glassy.

Another point to be observed is that although the typical character of a crystal is homogeneity, we more often find in the case of those crystals which occur in rock sections that perfectly transparent homogeneous crystals are the exception not the rule, and that in most cases the crystals under observation are full of foreign material; inclusions, some of which may have been contemporary with its formation, but others which have been subsequently produced, some of these will often afford valuable indications as to the conditions under which the crystal was formed, and the changes which have since its formation passed over it.

1t is sometimes difficult to tell whether a particular crystalline body is a single crystal or merely a crystalline aggregate. The polariscope will at once reveal the difference by breaking up the aggregate into its component parts, which will appear variously coloured; a single crystal being of an uniform or nearly uniform tint, its difference, if any, depending merely on its unequal thickness. Some observations may be made with the polarizer alone, the analyzer being removed, thus the dichroism of certain minerals is determined in this way. Hornblende may by this means be discriminated from augite, biolite is

also seen to be strongly dichroic, and by its marked dichroism is readily distinguished from hornblende, which is indeed rather pleochroic than dichroic. Again the metamorphosis frequently present in some of the constituents of a rock is well shown by means of the microscope, as for instance the olivine, a common mineral in the dolerites, is not seldom found to be undergoing a gradual transformation into serpentine, from which it has been surmised that when a rock is highly charged with olivine, this metamorphic action may sometimes be so extensive as to cause the change of the entire rock from dolerite or basalt into serpentine.

We may gather then that when the structure of a rock has been carefully determined, we shall hold the key which will enable us to open the secrets of its history, the modes of its formation, and the origin of the rock itself.

It is very important that we should learn to discriminate between minerals which belonged to the rock at its original formation and those of secondary character, and it will appear that certain crystals have separated from the magma at a period quite different from that of the formation of the other crystals, and the only way in which we can ascertain to which class certain minerals belong is by studying the relations which they bear to one another as seen under the microscope. Noting the position of the several crystals of the different minerals which have separated during the same period of consolidation, we shall observe that crystals of one mineral are often enclosed in those of another species, and again, the crystalline form of one mineral will be produced at the expense of others, so that we shall be able to establish the order in which they were crystallized.*

By means of the microscope we have the power to unravel the minute details of structure in the finest grained rocks, be they basalts or slates, or any analogous forms. We shall at once be enabled to distinguish one rock from another, say dolerite from diorite, the peculiar behaviour of the hornblende in the latter being so ma_ked that it cannot be mistaken for the augite of a dolerite.

The microscope will also show us how closely allied certain rocks

* Prof. Judd, Q. J G. S., Vol. xlii., pt. 1.

are, although separated by a vast chronological interval, and we shall be able to correlate the older igneous rocks of palæozoic age with the tertiary anamesites, basalts, and dolerites, and even with the products of still active volcanoes.

We will now turn to some of the chief peculiarities of the igneous rocks, with a view to their microscopical examination. The igneous rocks may be divided chemically into two great classes, the acid, and the basic, the former containing 60 per cent. and upwards of silica, a much higher per-centage than the latter. The felspar in the former is chiefly orthoclastic, in the latter it is plagioclastic. The principal rocks in the acid series are, first, the crystalline, such as granite, felsite or felstone, and trachyte, etc. The granites consist of quartz, felspar (orthoclase and oligoclase) and mica, which latter mineral is often replaced gradually by hornblende, and when this is the prevailing element the rock becomes syenitic. In granite we may meet with various adventitious minerals, some the result of changes going on since the rock was formed; amongst the adventitious minerals will be found pyrites, marcasite, chalcopyrite, garnet, apatite, epidote, and occasionally calcite, etc. Felsites and felstones are rocks very various in colour, composed of quartz and felspar (orthoclase) together with some easily decomposable mineral which takes the place of the mica or hornblende of the granites. The granitic form of felsite is called eurite. The compact varieties are known as felstones. The second division of rocks in the acid class is the glassy, the representatives are pitchstone and obsidian.

The basic rocks also consist, first, of crystalline forms, the chief being gabbro and dolerite, and its varieties anamesite and basalt; gabbro is composed of plagioclase felspar, frequently labradorite, known by its opalescence when occuring in masses, diallage or some other pyroxenic mineral, such as hypersthene or augite, and olivine. Amongst the adventitious minerals are magnetite, pyrites, marcasite, chalcopyrite, biotite, garnet, apatite, epidote, serpentine, chlorite, nepheline, nosean, leucite, calcite, etc. When the diallage is replaced by augite, and the rock is granular, it is called dolerite; finer-grained varieties are anamesite and basalt. The glassy form of basic rocks is

known as tachylite.* Besides all the above-mentioned rocks, there is also an intermediate series, which frequently occur as intrusive masses or dykes, thus we have diorite, a rock composed principally of felspar and hornblende, also syenite; porphyrite and phonolite are lavas which may be classed with these.†

Turning now to the microscopical structure of these rocks, we frequently find in them a vitreous or glassy base enclosing crystalline minerals; such a glass appears on a large scale in obsidian and the pitchstones and in tachylite. Now we have seen that a glass under the microscope presents no trace of structure, when the polariscope is used there is no double refraction observed, such as is exhibited by all crystals except those of the cubic system. "Felspar may appear dark at the same time, but if the polarizer is rotated a few degrees and the prisms again crossed by moving the analyser, the felspar will transmit light." Thus a felsitic base, which at first glance might appear to be vitreous will show double refraction. When polarised it will break up as the prisms are rotated into variously coloured little particles, and is seen to be a granular compound of crystalline fragments, amongst which are a few more or less perfect crystals. Such a base is met with in felspar and in many other rocks. Again, the quartz of granite may at first sight be mistaken for a glassy base, as it is usually found without the angular form of crystals, having been the last mineral to crystallize, and therefore is modified by the others. It appears to be structureless, only containing numerous fluid and other cavities. But directly it is examined with polarised light its true character is revealed by the gorgeous display of colours it presents, broken into irregular patches, some of which show round their edges parallel wavy bands of colour,

* Both in the Acid and in the Basic rocks a gradual passage may be traced in some districts from highly crystalline through less crystalline into glassy forms, and a gradation on the one hand has been shown to exist from granite through quartz felsite, and rhyolite into obsidian, and on the other from gabbro into dolerite basalt and tachylite, such changes having resulted from the varying conditions under which the rocks had consolidated. (Judd, Q. J. G. S., vol. xlii., pt. 1).

† In the case of these rocks also an insensible gradation has been traced from holo-crystalline to glassy conditions, as from diorite into vitreous andesite.

marking out the individuality of the quartz grains, and showing the way in which they consolidated in independent masses.

We will now proceed to illustrate our subject by noting the microscopical characters of some of the chief minerals occurring as rock constituents, pointing out some of the distinguishing marks by which they may be recognised. Let us first take Quartz.—Its appearance when it occurs as a base or in granite has been already noticed, but this mineral is frequently found distinctly crystallized, the crystals being porphyritically embedded in a felspathic matrix. Such crystals may be at once known by their form, and by the magnificent unbroken colours displayed when polarised light is used. The peculiar concentric bordering of brilliant colours round a single coloured centre has already been mentioned as characteristic of quartz when found without a definite crystalline form, colours owing to the decreasing thickness of the edges. Cavities, some of them water ones, abound in it.

Crystals of Felspar may be very easily recognised in most cases by their form and optical behaviour. The felspars are divided into two groups, according to their crystallographic system, the orthoclastic, in which the principal cleavages are at right angles to each other, and the plagioclastic, in which the planes of cleavage are at other than right angles. These latter are often termed triclinic, to distinguish them from the monoclinic or orthoclastic group. Under polarised light it is as a rule not difficult to distinguish between the two groups.

Sanidine is a transparent form which may be known from common orthoclase by its pure transparency, it is also frequently very distinctly crystallized. Sometimes, however, its crystals will be found to enclose other minerals, such as augite, nepheline, magnetite, etc., and long needle-shaped crystals (belonites) are not unfrequently met with. Broken crystals of sanidine are often found enclosed in a trachytic base, from which we gather that they were already formed whilst the mass was in motion.

Orthoclase, whilst presenting nearly similar forms to those of sanidine, differs from it in being very seldom clear. When polarised it often shows a remarkable irregular-banded structure, the

bands being interrupted and crossed by others, giving a grating-like appearance. The bands or striæ run at right angles to each other. Twin crystals of the Carlsbad type are common in orthoclase. Enclosures of other minerals are abundant in this felspar, although from its general opacity it is not easy to recognise their species.

Turning to the next group, the Plagioclastic Felspars are easily distinguished when the polariscope is used, by their splendid banded appearance, parallel bands of colour are seen, which are due to the polysynthetic or twinned crystallization, which is highly characteristic of this mineral species, although this structure must not be regarded as essential, since we may not unfrequently find plagioclastic felspars, anorthite, oligoclase, and even labradorite, which exhibit no trace of lamellar twinning, a structure which is considered by several eminent petrographers to result from pressure or strain, and not to be invariably an original character. When we examine the varieties of mica which occur in rock formations, we find that two of them are most common, Muscovite, or potash mica, and Biotite, or magnesia mica. The former, which is optically biaxial, forms tabular hexagonal crystals. Under the microscope it is transparent and shows bright colours, and its sections generally exhibit a chaos of fine lines or of Newton's rings on the surface, marking the boundaries of its torn leaves. This mica is but slightly dichroic, manifesting only clearer or darker tints of the same colour. Biotite or uniaxial mica, has also hexagonal crystals, it generally occurs in thin irregular or polygonal leaflets or in elongated tables, its colour is black or dark green or brown. The leaflets present a smooth glistening surface, but the tables which are cut across the edges of the leaflets are laminated. The leaflets which are cut at right angles to the short axis are dark between crossed Nichols. Those cut parallel to the axis only become so when the direction of their striæ is parallel to the chief diagonal of the prism. Biotite is strongly dichroic, and this is its most characteristic microscopical feature.

Chlorite may often be seen in igneous rocks, in the form of little green leaflets and scale-like aggregations. Its leaflets are frequently arranged in vermicular or radiating forms caused by a partial overlapping. It is also found in concentric layers. Some-

times the leaflets seem to consist of twisted or irregularly interwoven fibres. In sections of the chloritic schists, the chlorite often occurs in scales, which look like green glass cavities. Now and then hexagonal scales will be seen, which remain dark when the polariscope prisms are crossed. The polarisation colours of this mineral are feeble, blue and brown tints being the most prevalent, it is also decidedly dichroic.

Hornblende is a very important constituent of some rocks. It occurs in distinct crystals, but is more often met with in crystalline masses and leaflets. Its structure is fibrous, and although it might at first sight be sometimes mistaken for biotite, the marked dichroism of the latter, as contrasted with the more feeble dichroism or rather pleochroism of the hornblende, will serve to distinguish between them. This will also enable us to distinguish between hornblende and augite. Transverse sections of the crystals of hornblende show two well defined sets of striæ, which are its planes of cleavage, and intersect at an angle of 124°30′, when the section is cut at right angles to the principal axis. Minute acicular crystals of this mineral are very frequently met with in the igneous rocks. Many adventitious enclosures occur in hornblende crystals, such as magnetite quartz, biotite, etc.

Another very important constituent of some igneous rocks is Augite. It is constantly present in the dolerites and allied rocks. Under the microscope it is readily recognised, its colour is brownish or yellow, and it is often very distinctly crystallised. Its crystals are frequently very much cracked in an irregular manner, the result of strain during consolidation; their sections are usually eight sided, which may help us to distinguish between them and those of hornblende, which are six sided. The double refraction of augite is powerful, and in thin sections it polarises with brilliant colours, it is also dichroic, the dichroism being of a purplish tint. Augite crystals often contain numerous enclosures, such as biotite, leucite, magnetite, etc. Occasionally the augite will be a mere cell-like crystal, filled up with a multitude of microscopic minerals. Augite also frequently occurs in the form of minute crystals, some curved, others club-shaped, or split into dichotomous points.

Diallage, when crystallised, corresponds with augite, but it is more often found in granular aggregations, and filling up or bordering cavities in the matrix; its colour is green or brownish. In sections it shows distinct striation paralled to the chief crystallographic axis, and a somewhat concentric structure is sometimes denoted by little colour rings. Like other minerals, enclosures are frequent in it. Diallage is only an altered form of augite.

Olivine is of frequent occurrence in igneous rocks, both in the older as well as in the more recent. Sections of olivine crystals under the microscope are greenish grey or colourless, and the mineral has a peculiar granulated looking surface, which becomes very distinct when polarised, having an opalescent appearance. The crystals are also frequently fissured. Along these fissures metamorphism is often seen, fibrous deposits of oxide of iron and of serpentine are common, giving the mineral a green reticulated look. Sometimes the olivine will be completely changed into serpentine. In some rocks hexagonal crystals of olivine occur, octagonal as well as unsymmetrical sections are also frequently seen, depending upon the angle at which they are cut. The angles of the crystals are often rounded. When occurring in basalts it has been observed that the olivine crystals are fragmentary, and the separated parts of individual crystals are often present, proving the motion of the enclosing mineral mass subsequent to their formation. Olivine is very generally met with as a pseudomorph, and the irregular patches into which it is resolved by the polariscope shows clearly the distinction between an aggregate and a single uniform crystal.

A common constituent of some of the lavas of Vesuvius, the Eifel and of a few other localities, is Leucite, a mineral which seems in part to replace the felspar of other similar lavas. It is also present in smaller quantities in some few other igneous rocks. It is easily recognised under the microscope, occurring either in rounded grains grouped together in bands, or in fine octahedral crystal sections. In small grains its behaviour is like a glass, but when occurring in larger masses it presents when polarised a very marked and characteristic appearance, viz.: interference spectra or lamellar polarsiation, which has already been described. The leucite crystals between crossed

prisms exhibit a remarkable series of parallel stripings of a dark or bluish grey tint, intersecting each other at an angle of 60° or 90°. On rotating the analyser the dark bands will become clear, and the bluish-grey will present the usual phases of doubly refracting crystals. Leucite generally contains very numerous enclosed microlites of felspar and augite, and granules of magnetite, etc., which are frequently found arranged in concentric rings or symmetrical zones, lying sometimes parallel to the boundaries of the crystal.

Nepheline, a frequent mineral in volcanic rocks, plays a very important part in some basalts and lavas. It occurs very generally in hexagonal or rectangular forms. The hexagons being cut at right angles to the vertical axis will not polarise, but sections which are parallel to it polarise with a brownish-yellow or light greyish-blue colour. What appears to be a fine grey dust is sometimes seen in nepheline crystals, which, with a high power, is resolvable into glass or fluid cavities. Very small green microlites, parallel to the long axis, are also found in nepheline. The enclosures are sometimes densely accumulated in the centre of the crystals. At other times they are seen to occupy zones parallel to their boundaries. Occasionally nepheline crystals exhibit aggregate polarisation, and entire crystals will be found converted into an aggregate of zeolites. An oily-looking green or pinkish variety of nepheline, which is seldom distinctly crystallised, is occasionally found to take the place of this mineral in the older igneous rocks, and may be considered in reference to nepheline, to be what othoclase is to sanidine, it is known under the name of Elæolite.

We may, in the next place, notice Apatite. It is somewhat difficult to distinguish between apatite or nepheline, but where the two minerals occur together it will be observed that the hexagonal crystals of nepheline are somewhat larger than those of apatite; and it may also be noticed that whilst nepheline occurs in short colourless rectangles, the apatite will form long colourless needles; both minerals are hexagonal, and by this may be distinguished from minute sections of felspar.

Sodalite is a representative of a group of isomorphic regular minerals found in volcanic rocks. Microscopic sections show

dodecahedral forms which are often very translucent, although they frequently occur filled with microlites and cavities, both gaseous, fluid, and glassy.

Another mineral occasionally present in some of the igneous rocks is nosean or hauyne, of which lapis lazuli is the well known blue variety. Its crystals are generally quadrangular or hexagonal, often irregular, and very generally filled with minute enclosures, which often form regular concentric bands, symmetrically following the planes of the crystal.

Epidote is of very common occurrence in granite and other rocks. It is frequently seen in elongated crystals, clouded with a dirty green colour. In some specimens its structure is radiated and fibrous, and polarises green, yellow and brown, in most cases. Now and then this mineral occurs in large crystals, filling up cavities in some rocks, as for instance in the diorite of Quenast, in Belgium.

Iron is abundant in all the igneous rocks, occurring as magnetite, hæmatite or specular iron, and occasionally as titaniferous iron. Curious little opaque clusters of magnetite are frequent, and translucent plates of hæmatite abound in some varieties of felspar; it is the light reflected from these that gives the variety of oligoclase known as sunstone, its beautiful opalescence.

Amongst alteration products, one of the most important is serpentine, which is often found in enormous masses. Under the microscope it has a very beautiful appearance, showing a confused reticulated net work of varied tints, and brush-like aggregations of needles may often be observed on the outer edge pointing inwards.

The microscopical behaviour of calcite has been previously noticed. This mineral is very frequently found as a secondary product, filling up cavities and fissures in the igneous as well as in other rocks, it is invariably a deposit from aqueous solutions. Often the amygdaloidal vesicles in trappean rocks, especially dolerite, are filled with calcite, and this is frequently surrounded by a coating of green chloritic material. Water cavities abound in the calcite, proving its secondary origin in such rocks, from solution in water, which has passed into the empty spaces which originally were gas bubbles.

Aragonite, another form of calcic carbonate, differs altogether from calcite by its cleavage, which, instead of being rhomboidal, is conchoidal, and under the microscope has a foliated appearance, which is well seen in some sections of Carrara marble.

Another secondary formation occasionally found filling amygdaloidal spaces is chalcedony, a variety of quartz. It is an exquisitely beautiful object when polarised, showing a minute crystalline radiated structure, gorgeously coloured, and presenting also fine illustrations of interference spectra.

Delessite is a mineral which is not unfrequently found in amygdaloids, either completly filling up cavities or else coating their sides. Under the microscope it has a concentric banded structure, with a radiating growth between the bands, or rather cutting through them. The concentric lines follow the outline of the cavities. The colour of this mineral is green, and it is transparent and pleochroic. Between crossed prisms the radial forms of delessite, especially sections across amygdaloidal enclosures, show the interference cross very beautifully.

Amongst the secondary formations in the volcanic rocks zeolites of various species are common, both filling microscopical as well as macroscopical cavities. In all of them we may observe the same tendency to a concentric or fibrous structure. Their natural colours are varied, yellow, brown and green tints being the most common, as well as white.

In studying the microscopical structure of igneous rocks, certain facts may be deduced, amongst which may be mentioned, that it will be possible to gather whether the rock was rapidly or slowly cooled; a rock full of minute crystals will have consolidated more rapidly than one in which these are large and well-formed. And rocks abounding in microlithic crystals may be considered to have solidified near the surface, or to have been ejected as molten lavas; whereas those in which the crystals are large would be slowly formed, cooling very gradually under pressure and probably at a considerable depth below the surface. Then, again, we shall gather that those crystals which are most perfectly developed will have been the first formed ones, and these will often be found to have considerably modified the formation of the others in the same rocks.

It has been noted that "the igneous rocks of the Tertiary and recent periods, as a general rule, exhibit far less perfectly crystalline structures than those which belong to the older formations. Again, the older the rock is, the greater the probability that its mineral constituents will have undergone alteration, sometimes this will be so great that hardly one will remain in its original form. Augite may be converted into hornblende, olivine and enstatite into serpentine, and so on. Also many rock forming minerals may be made," as Professor J. W. Judd has pointed out,* "to assume new and unfamiliar aspects by the developement of enclosures along certain planes within their crystals." Thus some pyroxenic minerals are seen to contain numerous enclosures in the form of thin plates and rods arranged along parallel planes in the crystals, these, when the crystals are looked at in certain positions, give it a peculiar semi-metallic lustre or "chatoyant" character, which is termed schillerization, thus diallage and hypersthene are shown to be schillerized forms of augite and enstatite, and Professor Judd observes that "the production of the schillerized condition is related to the depth at which the crystals have originally existed; schillerized forms being found only in deep-seated intrusive masses. The solvent action of heated water and other fluids acting under great pressure attacks the crystal along certain planes, not always cleavage planes, but of chemical weakness, negative crystals are thus formed which become filled with the products of decomposition."

In the older igneous rocks of Palæozoic age it not unfrequently happens that the whole of the original minerals will have been converted into pseudomorphs, partly by deep-seated action, partly by atmospheric agencies, and often as the rock is traced from within outwards, the alteration will be found to increase. Where extreme change has taken place it will sometimes be possible to infer that a given mineral has once formed part of a rock, by the characteristic enclosures which are found in the alteration products.

Another point which has been made out is that there are distinct petrographical provinces within which the rocks erupted during any

* Q. J. G. S., vol. xli., pl. 3.

particular geological period present well-marked mineralogical or microscopical peculiarities which distinguish them from rocks belonging to the same general group which were simultaneously erupted in some other provinces.*

Having thus briefly noted the characters of some of the principal features of the igneous rocks and their associated minerals, as exhibited by the microscope, we may pass on to a short consideration of the general microscopical characteristics of the aqueous rocks.

In looking at these we shall be at once struck with the very different appearance presented as compared with those of igneous origin. Take for instance a thin section of a sandstone, no matter how fine-grained it may be, we shall at a glance perceive it to be an aggregation of particles, more or less rounded and water-worn, of quartz and other minerals, evidently derived from the breaking up of other rocks. Clays, shales, and most of the slates present a somewhat similar appearance, although with a more minute structure, which in the slaty rocks is sometimes considerably modified by the effects of pressure, as well as by other agencies, since their first deposition as sediments. Again the microscope will in many of these aqueous rocks bring to view traces more or less distinct of organisms. Some of the clays and shales, and especially the limestone, will be found to contain foraminifera, diatomaceæ, and other minute forms of the life of the geological period to which they belong.

The aqueous rocks may be conveniently divided into two groups, the non-calcareous and the calcareous.

The former have been derived from the breaking up of rocks of earlier date, in the first instance those of igneous and metamorphic origin, thus when we come to examine the materials of which they are composed, we find that they are the same minerals for the most part with which we have already been made familiar in our study of the plutonic and volcanic rocks, only comminuted, broken, and more or less rolled and water-worn, and sometimes corroded and partially decomposed. A careful study of the individual particles of a sedimentary rock will enable us very often to trace its origin. The common non-calcareous rocks are the sandstones and grits, and

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* Judd, Q. J. G. S., vol. xlii., pl. 1.

quartzites, clays, shales, and slates and schists. The prevalent minerals in these will be found to be quartz, mica, and various species of felspar; the felspars, as well as other minerals occasionally seen, are frequently decomposed and pseudomorphosed. In sandstone and grit rocks a microscopical examination of the conditions of the structural grains will afford some clue as to their antiquity; some sands will present grains only partially worn, whilst others will be built up of more or less angular grains; by observations of this sort Dr. Sorby has pointed out that we may "learn whether sand is of recent and comparatively local origin, or of very ancient, and transported far from its original source by drifting along the bottom." The presence again of fractured grains will sometimes "indicate some unusually violent local action."*

Slates need to be very closely examined in order to ascertain their character, whether those we are investigating are a mere aqueous sediment, formed by the disintegration of older rocks, or whether they are a volcanic ash. The microscope applied to the coarser varieties will enable us to decide the question; also, whether as regards the former class, the slate was derived from a coarse-grained granite or felsite, or from a fine-grained micaceous rock; the coarser rock would, Dr. Sorby has shewn, yield a kaolinitic clay-slate, whilst the finer one would originate a micaceous clay-slate, since the mica in such fine-grained felsites, etc., would not be separated from the kaolin, as it would be where occurring in larger flakes or leaflets, which would be left behind with the quartz grains as sediments were formed to produce micaceous sandstones and grits.

In the case of an ash, the coarser portions of a slate will show that it does not consist merely of the broken fragments of some older rock, but there will often be direct evidence of an igneous origin, such as the presence of pumiceous material, whilst numerous gas cavities will be found both in the felspathic crystals and in portions of the base. In some of the slates of the North of England pumice occurs in fairly large fragments, having its cavities filled with calcite.

* Q. J. G. S., vol. xxxiv., part 2. "On the Structure and Origin of Non-calcareous Stratified Rocks," by Dr. Sorby, F.R.S., etc.

Turning to the second or calcareous group of aqueous rocks, we have before us a large and very interesting field for microscopical research. The greater part of the limestone rocks is organic in its origin, that is to say, it is built up out of comminuted shells, corals, and foraminifera. We have but to look at a slab of the common fossiliferous limestone of Derbyshire to perceive without any instrumental aid that it is one dense mass of broken organisms, encrinital stems, fragments of shells, etc., and the microscope will show that finer-grained parts are equally full of minute foraminifera, and other remains of an abundant fauna existing once in the carboniferous sea. It is the same with many other limestones. Dr. Sorby in his very interesting address to the Geological Society of London, in 1879, entered with some minuteness into the question of the origin of limestones and their structure, and he observed that in studying these rocks a knowledge of the differences in the mineral constitution of calcareous organic bodies is very essential. In order to gain such knowledge both chemistry and the microscope have to be employed. He has pointed out that in the structure of shells the two forms of carbonate of lime aragonite and calcite occur, sometimes also some phosphate. One somewhat important point connected with this is that whereas calcite is a stable, aragonite is an unstable condition of carbonate of lime; shells in which calcite is the prevailing material would be more readily preserved than those formed of aragonite, and the absence therefore of the remains of species in which aragonite occurs would not prove that such species were non-existent in the fauna of a given formation. "Thus then a knowledge of the structure of fossil shells and other organisms necessarily assists us much in studying the fragments which constitute so large a part of many limestones."

Again, there are limestones whose origin is distinctly chemical, the carbonate of lime, or magnesia, has been precipitated from solution, or in the case of dolomite, the carbonate of lime may have been partially replaced by magnesia. Microscopical structure alone will not suffice, however, to enable us to determine whether the rock under examination is of organic or chemical origin. Some limestone

rocks also have been so greatly altered, that although they may have been once highly fossiliferous, all trace of organic existence has been removed and they present a mass of mere crystalline material.

Calc tuff, which is really a chemical precipitate, will often be found upon microscopical examination, to contain remains of confervæ and diatomaceæ which have been enclosed in it, upon dissolving it in hydrochloric acid the confervæ may be found in the residue, whilst the diatoms will have been dissolved. Oolitic limestones show an interesting structure under the microscope, the concentric character of the grains and the accumulation of the crystalline prisms of calcite around a nucleus, a grain of sand or a foraminifer, is well seen. Some oolitic grains will be found to be concentric, others radiated, and a third class recrystallized.

Chalk will abundantly repay the microscopist who will devote time to its study. A vast abundance of foraminifera, fragments of shells, polyzoa, echinodermata, and sponges will be found to constitute this rock, which is a perfect treasury of organic wealth.

Here this outline of an important branch of microscopical research must come to a close, much more might have been said upon every branch of the subject, some points have been altogether omitted which might have been alluded to, but enough, I trust, has been said to show what a wide field here lies open to the diligent student, on every side questions are yet awaiting answers, and beyond all doubt many cannot receive them until the microscope has been carefully employed. For details and for a full investigation of the subject the student must be referred to the elaborate works and papers of such men as Sorby, Bonney, Teale, Rutley and others, in this country, and to those of Zirkel, Rosenbusch, Renard, Fonqué, Levy, and many others on the continent.

ON PREHISTORIC REMAINS RECENTLY DISCOVERED IN WENSLEYDALE.

BY W. HORNE, LEYBURN.

Wensleydale, in the North Riding of Yorkshire, extends nearly east and west, with a length of about thirty miles; it is from two to three miles in breadth, and is one of the most fertile valleys in England. Yoredale was the ancient name of the valley, before the Saxons built a church at Wensley, and gave the Saxon name, Wensleydale, to it. The river retains its ancient name the Yore. The market town of Leyburn stands on the north side of Wensleydale, 650 feet above sea level. The town is built upon the twelve fathoms or main limestone of Phillips' Yoredale series; the beds gradually dip to the east. The limestone is only ten feet thick, having been denuded during the ice age. On the north platform of the Leyburn railway station there is a fine shelf of limestone rock exposed, showing striæ and scratches in an easterly direction, with boulders and drift overlaying it. To the west of Leyburn the shawl is a bold limestone terrace, extending almost unbroken for a distance of two miles, gradually rising until a height is attained of 870 feet above sea level. The limestone at this point is about sixty feet thick, forming a very bold escarpment overlooking the valley, and forms the celebrated walk called Leyburn Shawl. The alternating limestones, gritstones and shales add greatly to the beauty of the district. About three-quarters of a mile to the west of Leyburn, and below the main limestone, there is a small plateau extending a hundred yards and varying from twenty to forty feet wide, this flat piece of ground rests upon a thick bed of shale which is gradually slipping down the brow of the hill. On the face of the uppermost slip I made a careful search in March, 1884, when I discovered a small piece of bone projecting, about 2 feet 6 inches below the surface. The bone I removed, and to my astonishment, found a number of small bones, in fact the entire remains of a human foot. I communicated this discovery to the Honourable W. T. Orde Powlett, and we then, after a few hours work, had the satisfaction of unearthing one of the earliest interments of this district, of which a careful record

has been kept. The skeleton was laid on the left side, with the knees a little drawn up, the head to the north. The bones were in a very soft state, much broken, and partly displaced. This may be accounted for by the long time they have been in the earth, and to the gradual slipping of the shale. The skull was crushed almost flat, the jaw broken, and the teeth nearly all lying loose; two of the teeth were slightly decayed, all shewing the result of mastication and worn flat on the edge. I put the skull together as well as the broken fragments would allow. Near the left shoulder we found a bone implement, made of a piece of deer's horn nearly two inches in length, the centre cut out, but leaving the ends complete. As far as I have been able to ascertain it is unique, no similar implement has hitherto been found in England, and as this appears to be something new, various opinions have been expressed as to its use, but in this instance I have held to my own, that it was a simple brace to fasten the skin cloak across the shoulders. Probably the owner was interred in the skin cloak, and this implement was used to fasten it. The position it was found in was just the one we should expect to find it if used for such a purpose.

We also found several bones of reindeer on the left side of the skeleton; the large bones had been split. Pieces of charcoal were scattered amongst the soil, but not in such quantities as is usually found with British burials. In March, 1885, accompanied by Mr. Powlett, I was fortunate in finding another interment ten feet to the west of the first one, and the same depth below the surface, two feet six inches. The skeleton was laid on the left side, head to the north, and near the skeleton we found a pear-shaped pebble, worn smooth. The bones very soft and broken; the skull crushed into fragments; lower jaw broken, but all the teeth either in the jaw or laid in close proximity; the whole of the teeth were sound and in good condition, but very hard, worn down in some cases to the base of the crown, and perfectly flat, evidence I think of having been worn down by some gritty substance conveyed into the mouth with the food. We have tested the ground in several places and found charcoal, split and broken bones, burnt stones and pot boilers, and I have no doubt this place was used as a camping ground for a very long period,

as well as a place to inter the dead. Sheltered by the high cliffs on the north, and overlooking the valley below to the river Yore, it is an excellent situation both for shelter and defence. The graves must have been very shallow when first made, as the lowest part of the refuse stratum is near the same depth, and we must allow a few inches for the accumulation of vegetable soil.

THE LADY ALGETHA CAVE.

The Cave is situated about one and a-half miles to the west of Leyburn, near the end of the beautiful walk on Leyburn Shawl, in the twelve fathom or main limestone, at about 870 feet above sea level. The discovery of this cave was almost accidental; while taking a walk with my young friend, Mr. C. E. Dixon, I observed a rather large rabbit-hole, and while examining the hole, the ground near it seemed to have sunk down a few inches; in walking over it the ground sounded hollow. I next examined the edge of the rocks, and found a small fissure; and about 12 feet below, I found a rabbit-hole going horizontally into the face of the rock, and a rotten tree stump just in front of the hole, I now felt sure the long looked-for cave was discovered; my impressions I communicated to the Hon. W. T. O. Powlett. We set to work, and soon satisfied ourselves that we had discovered a genuine cave, filled up to within 6 inches of the roof. While removing the earth from the entrance of the cave we found a quantity of charcoal, broken bones, and burnt stones; also, a small fragment of Roman Samian pottery, about one foot below the surface, and just outside of the cave; it is evident the cave was filled up when this piece of Roman pottery was placed there. The whole of the earth has been cleared out for about 20 feet, the whole length of this small cave. The entrance is only 4 feet 4 inches wide, by 4 feet high; but inside 7½ feet high, and 5 to 7 feet in width; about 10 feet beyond the entrance the roof had broken down, thus causing the depression on the surface, near the rabbit-hole that first took my attention; the lower part of the cave was filled with clay, while the upper part was filled with cave earth and stones; but throughout we found teeth and bones of animals, and charcoal. At the bottom of the Cave there is a fissure varying from 7 to 12 inches wide, filled with clay; in the fissure we found near the whole jaw

with teeth of the wild ox, besides other bones. I think this fissure will go through the limestone, and possibly connect a lower cave with the one now opened, but this we have not at present proved.

The bones of the following animals have been found inside the cave :—rabbit, hare, hedgehog, water-rat, fox, sheep or goat, pig, red deer, wild ox, human lower jaw broken in three pieces, and found at a distance from each other ; when put together they formed one complete jaw, but several teeth were wanting ; it evidently belonged to a young person, because the wisdom teeth had scarcely come through. I think it very probable that this jaw had been carried into the cave by some animal, as we found no other human bones. The whole of the bones have been identified by Mr. Wm. Davies, of the British Museum. I have no doubt the cave, although so small, was inhabited by man, as well as animals, at different periods ; outside the cave we find evidence of fire, burnt stones and charcoal, inside we found several broken pieces of slightly burnt pottery, some of it only dried, and the coarsest I ever met with; and several millstone grit pounders, or rubbing stones. The presence of these stones in the cave I cannot account for, except they were taken in by the occupiers of the cave ; we found no flint implements, or metal of any kind. A photograph of the entrance of the cave was taken by the Hon. W. T. O. Powlett while the work was in progress. The cave was named the Lady Algetha Cave in honour of Lady Algetha Orde Powlett, who was the first lady who honoured us with a visit. Nearly the whole of the objects found in the Cave, as well as in the ancient burial and camping ground, are deposited in the Hon. W. T. O. Powlett's museum, now in progress of formation at Bolton Castle.

The remains of small housesteads of various sizes are found in several places in the Dale, but always upon the gritstone formation, gritstone being selected in preference to limestone because it was easier to form a rude wall with, as the stones are a more convenient size and drier than limestone; another reason why they should select gritstone is that it rests upon a plate or shale which always throws out the water that passes through the limestone or gritstone beds, so they were sure of a good supply of water close at hand,

often within their enclosure. The housesteads occupied am iddle position between the river and the top of the hill. The people who occupied these housesteads are later than those that lived on the camping ground and in the cave, as we find in the latter no bronze or iron, while in the housesteads referred to both bronze and iron have been found.

NOTES ON THR POLYZOA OF THE WENLOCK SHALES, ETC.

BY GEORGE ROBERT VINE.

PART I.

Polyzoa (or bryozoa) from the upper and lower Silurian horizons of America have been described by Mr. James Hall and Professor H. A. Nicholson, and the bryozoa of the Cincinnata and Minnesota group of rocks have been systematically worked out by Mr. E. O. Ulrich. But even now we are unable to correlate, satisfactorily, palæozoic with the earlier mesozoic, much less with cretacious or tertiary forms. First, the most characteristic of the palæozoic polyzoa have peculiar facies. In the Silurian rocks we meet for the first time with fenestrated forms with two individualised characters, one with branches united by disseppiments, and another by inosculation. Both these types are persistent throughout the whole of the palæozoic series, whether in this or in other countries, while an equally persistent pinnated type begins low down in the series, and increases numerically and specifically till they reach the apex in the carboniferous rocks, both groups gradually fading away in the Permian, and are entirely unknown in the mesozoic epochs. The peculiar Ptilodictya group begins in the earlier Silurians, and fades away before the close of the Devonian period, while another form, the Cystodictya, dies out entirely in the carboniferous limestone series of rocks. All the species of these various genera are well marked and distinct, and rocks may be characterised whenever individual specimens are present. In describing any one of the species of these groups there is only one element of structure

that is available for special detail, that is the cell; growth and habit are less essential, but of relative importance, if the characteristic cell arrangement is well and carefully studied. In the following notes the whole idea of classification is built up from the knowledge of the structural arrangement of, or disposition of the cells, and the few characters associated with them. This will be more observable in a division of the Polyzoa which I have been compelled to found for the reception of certain species. There is one group of Polyzoa in the Silurian rocks, abundant both in this country and in America, the Stomatoporæ, that seems to link the Silurian with the mesozoic and later epochs, though species of Stomatoporæ are unknown, up to date, in the carboniferous series; while the Ascodictyæ which are abundant in the Wenlock shales, and rare in the Scotch carboniferous shales, are present both in the Silurian and in the Devonian rocks of America. Species of this group may ultimately be regarded as the palæozoic representatives of the stoloniferous Ctenostomata; to some of the recent forms of this sub-order they bear a very close resemblance. Of the Cheilostomatous group of polyzoa, so abundant and diversified in the present seas, I know of no forms by which, apparent palæozoic types could be linked together, and it is very questionable whether the sub-order with all the varied characters now recognised by the systematist, had an earlier beginning than the middle jurrassic. Modified Cheilostomatous features may have existed however in the Fenestelidæ of the palæozoic rocks.

Secondly, there are throughout the whole of the palæozoic rocks, both in this country and America, a very peculiar group of fossils, which are differently regarded, systematically, by different authors. One holding that the group belongs to the Bryozoa, another to the Cœlenterata, I mean the Monticulipora, but as the whole systematic question of generic or specific affinity has been ably discussed by Professor H. A. Nicholson in his admirable monographs, (Tabulate Corals, 1879—and the genus Monticulipora, 1880.) I refer the students to these works for special details. At the same time it must be admitted that elaborate details on the American species, pointing in an opposite direction, are furnished by Mr. E. O. Ulrich (Journal of the Cincin. Soc. Nat. Hist., 1882-1885) in his various

papers, and it is only fair to say that both he and Mr. James Hall regard some if not all the members of the Monticuliporidæ group as bryozoons. It is to this group, species of which are abundant in the Wenlock shales that I wish to direct attention in the after part of my serial papers, and though I am inclined to agree rather with Prof. Nicholson, than with American authors generally, I will accept the American work for my present labours, for the sake of the admirable details so honestly worked out by Mr. E. O. Ulrich and by Mr. Hall. By adopting this method I shall be able to publish descriptions of the British species, and correlate American and British forms that would not otherwise be possible. Of the classification of the Polyzoa proper, the Cyclostomatous species especially, I have followed my own arrangements as formulated in the 4th Brit. Association Report on Fossil Polyzoa, 1883. This part of my labours differs but slightly from that of Mr. E. O. Ulrich, but in the new sub-orders, independently established by us, our arrangements differ greatly ; this however will be pointed out further on.

I have not, in this part of my papers, redescribed species that were previously worked out and published elsewhere, but notes and full references are given. It will be in the latter part of this series that original investigation will be introduced.

Class Polyzoa.

Bryozoa (part), Hall, Ulrich, Prout and Authors.

Bryozoa, Ruess, Manzoni, Waters, &c.

Polyzoa, Nicholson, Busk, Hincks, &c.

Order I. Phylactolemata, Allman.

Unrepresented in a fossil state.

,, II. Gymnolemata Allman.

Sub-order I. Paludicellea, (fresh water). Unrepresented.

,, II. Cheilostomata, Busk. Unrepresented (?)

,, III. Cyclostomata, Busk. Prevailing sub-order.

,, IV. Ctenostomata, Busk. Unrepresented (?)

,, V. Cryptostomata, Vine. For palæozoic species.

Of these sub-orders of the Gymnolemata, only the third and fifth so far as is at present known, are represented in the palæozoic rocks

As some authors* have expressed an opinion that possibly Cheilostomatous species existed in palæozoic times, I have placed a (?) rather than affirm dogmatically that the sub-order did not exist. In Messrs. Young's paper on carboniferous species of Polyzoa,† the authors refer to a sub-oral pore in Glauconome stellipora, Young and Young remarking that as the smaller opening "cannot be regarded as that of the ovicell, the only other structure to which it can be compared is an avicularian appendage, and if this view be correct, some at least of the palæozoic polyzoa would belong to the (sub) order Cheilostomata, thus adding another to the list of persistent ordinal types." Mr. Ulrich. however, in his scheme of classification‡ adds the following—"sub-order Cheilostomata, Busk, Fam. Membraniporidæ, Busk . . . ? Paleschara, Hall. Zoarium incrusting; tubes very short. Cell apertures direct, angular, and more or less oblong. Cincinnati to Lower Helderberg." And recently Mr. A. W. Waters‖ remarks, in his paper on Fossil Cyclostomatous Bryozoa from Australia, "Among the palæozoic fossils there is in one or two a structure which may represent the suboral pore or avicularium, and so long as we do not know the signification of the adventitious tubules of Diastopora obelia, we may be justified in asking if they may not possibly have had an homologous origin."

Sub-order, CYCLOSTOMATA, Busk.

Cyclostomata Busk, Brit. Mus., Cal. pt. iii. : Crag Polyzoa ; Hincks, British Marine Polyzoa, p. 416.

Tubuliporina, Milne Edwards.

Auloporina, Myrioporina, (part) Ehrenberg.

Cerioporina, (part) Bronn.

Centrifuginea, (part) D'Orbigny.

Zoœcia tubular, with a plain inoperculate orifice (normal), or with closure§ (Waters). Marsupia and appendicular organs (avicularia and vibricula) wanting.

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* Messrs. Young of Glasgow, and Mr. Ulrich of America.

† Quart. Journ. Geol. Soc, Dec. 1874, p. 683

‡ Cincin. Soc. Nat. History (Journal) Oct. 1882, p. 157.

‖ Quar. Journ. Geol. Soc. Vol. 40, p. 675.

§ See paper on the "Closure of Cyclostomatous Bryozoa," Jour. Linn. Soc. Vol. xvii. p. 400, &c., pl. xvii.

I have included in the above description of this Sub-order the reference to the "closure" of certain cells which cannot, however, be characterised as an operculum in the sense generally applied by writers on Polyzoa.

Family I.—Stomatoporidæ, Vine.

Report Brit. Assoc. on Fossil Polyzoa, 1883.

Zoarium entirely adherent, simple or branched. Zoæcia arranged in a single series, or in several, which take a linear direction generally.

Genus I.—Ascodictyon, Nicholson and Etheridge, Jun.

" II.—Rhopalonaria, Ulrich.

" III.—Stomatopora, Bronn.

Sub-genus Proboscina.

Genus I.—Ascodictyon, Nich. & Etheridge, Jun.

Ascodictyon Annals and Mag., Nat. Hist., Ser. 4, vol. xix., pp. 463-468, pl. xix.

Ascodictyon, Vine. Notes on Polyzoa of the Wenlock Shales, Quart. Journ., Geol. Soc., Feb. 1882.

Ascodictyon, Vine. Notes on species of Ascodictyon, and Rhopalonaria, Annals Mag., Nat. Hist., Aug., 1884.

Ascodictyon, Vine. Brit. Assoc. Report, Fossil Polyzoa, 1883.

Generic Characters. Organism composite, adherent: composed of calcareous cells or vesicles, the walls of which are perforated by microscopical foramina, but which possess no single large aperture. The cells united by short tubular necks or disposed in clusters and connected with one another by hollow filamentous threads, which usually anastomose, and which in some cases at any rate, are likewise perforated by microscopic pores.

1. Ascodictyon filiforme Vine. Plate XII., figs. 1 to 4.

A. filiforme, Ann. Mag. Nat. Hist., pp. 78-80 fig. 1.

A. filiforme, Vine, Quart. Jour. Geol. Soc. Feb. 1882. p. 54.

Habitat: On broken shells and stems of crinoids.

Localities. Buildwas beds, Wenlock shale: Shales above Wenlock limestone, but rare.

2. Ascodictyon radiciforme Vine. Pl. XII., figs. 5 and 7-10.

A. radiciforme Vine, Quar. Jour. Geol. Soc., Feb., 1882. p. 53, f. 3.

A. radiciforme Vine, Ann. Mag. Nat. Hist., Aug., 1884, p. 82, fig. 3, No. 1-6.

A. radians? Nich. and Eth. Quar. Jour. Geol. Soc., Nov. 1881, p. 619.

Habitat: On stems of crinoids and fragments of shell.

Localities: Buildwas beds, Wenlock shale, Shropshire.

3. Ascodictyon stellatum, Nich. and Eth. Jun.

Var.: siluriense, Vine. Pl. XII., fig. 6.

Ascodictyon stellatum Vine, Quart. Jour. Geol. Soc., Nov., 1881, p. 618.

A. stellatum, var. siluriense Vine, Quart. Jour. Geol. Soc., Feb. 1882, p. 52, fig. 1-2.

A. stellatum, var. siluriense Vine, Ann. Mag. Nat. Hist., Aug. 1884, p. 81, fig. 7.

The colonies of this peculiar species are very abundant in the shales, and though it is found in other localities than the one given below, still the most typical forms have a very limited range.

Habitat: On stems of criniods and broken shells, and sometimes, though rare, on corals.

Locality: Buildwas beds, generally.

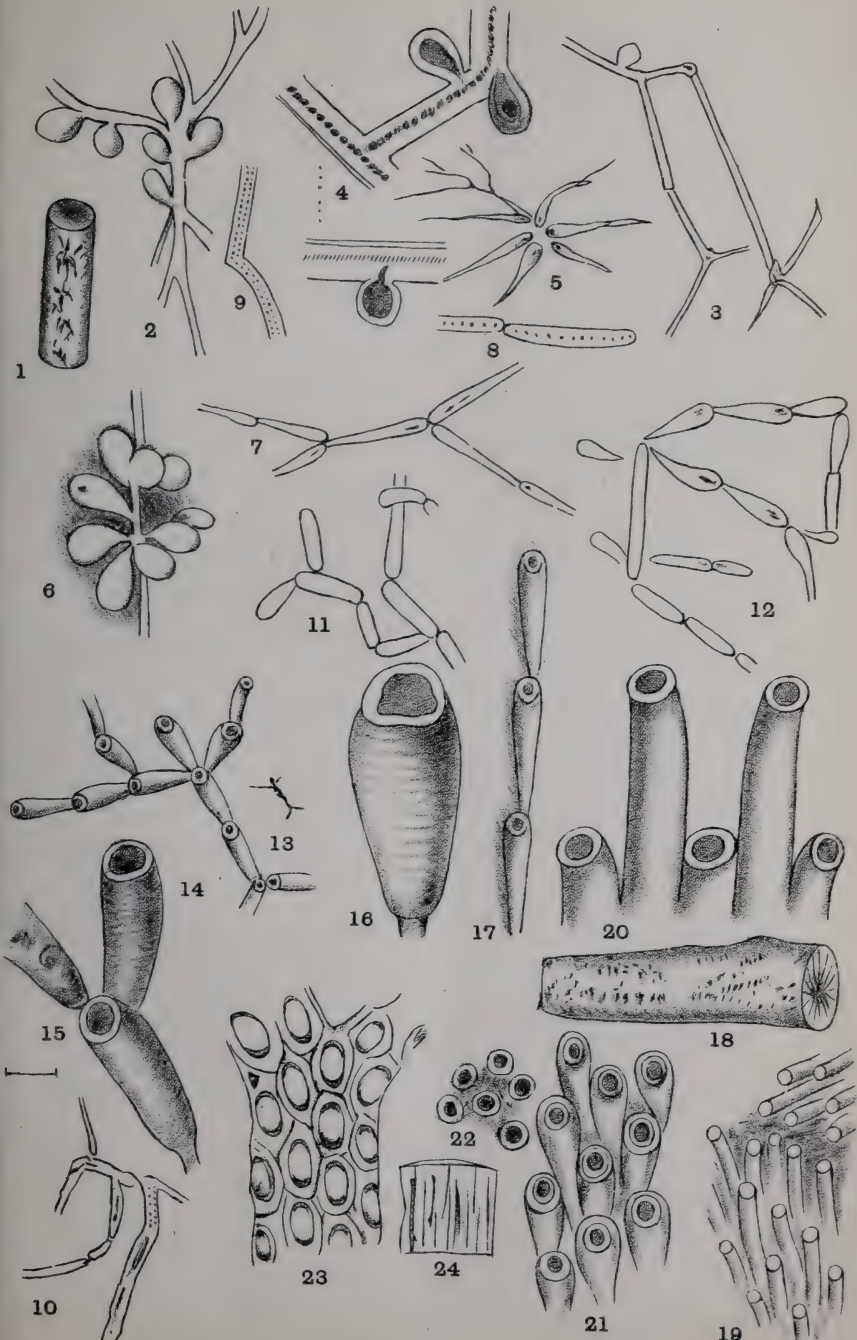
Range: Hamilton formation (Middle Devonian) of Widder, Ontario (Nicholson).

4. Ascodictyon radians, Nich. and Eth. Jun.

A. radians Nich. and Eth. Ann. Mag. Nat. Hist., June, 1877.

A. radians, Vine (Observations) Quart. Jour. Geol. Soc., Feb., 1882, p. 54.

My own specimens of this peculiar species differ considerably from those described by the authors in their joint papers. The elongated vesicles are less attenuated, and the fenestrate filiform threads which cover very compactly the stem of the crinoid on which colonies are found, resemble rather closely the clustered forms of Ascodictyon filiforme of the Wenlock shales; then again, the stellate rosettes which are found upon the stem, show a very close relation-



UPPER SILURIAN POLYZOA AND ASCODICTYÆ.

ship to A. stellatum Nich. and Eth., but which would not upon close examination be mistaken for the Devonian species.

As the authors remark (p. 466) "there appears to be two well-marked varieties amongst the forms which we have placed under A. radians.

Var. *a*. Vesicles few, lobate, and larger than in *b*.

Var. *b*. Vesicles very numerous, smaller and finer than in *a*, and the individuals always more crowded together."

The above, then, will form another variety of A. radians Nich. and Eth., rather than a distinct species.

Habitat: On crinoid stems.

Localities: Carb. limestone group. Boghead Quarry, near East Kilbride; Calderwood shales (Nich. Eth., jun.; James Bennie); Hairmyres shales (Vine).

Range: Though allied to the other forms of Ascodictyon referred to above, I consider that typical A. radians is in this country at least, peculiarly carboniferous. As yet I have not found it in any of the English or Welsh shales or limestones.

Genus II.—Rhopalonaria, Ulrich.

Ropalonaria, Ulrich. Jour. Cincin. Soc. Nat. Hist. Vol II., p. 2.

Rhopalonaria, Vine. Ann. Mag. Nat. Hist., Aug., 1884, p. 84, &c.

Zoarium creeping, adnate branched, forming a close and delicate network. Branches linear, cells uniserial, elliptical or botelloid and joined together at their contracted or rounded ends. (Ulrich, slightly extended).

5. Rhopalonaria botellus, Vine. Pl. XII. typical fig. 11, mixed features, fig. 12.

R. botellus Vine. Ann. Mag. Nat. Hist., Aug., 1884, p. 85, fig. IV., 3.

Colonial growth, either botelloid or rhopaloid in character, forming clusters of cells either fenestrated or free, and attached by their elongated or rounded ends.

Habitat: On shells, corals, and crinoid stems.

Localities: Typical forms, Buildwas beds, but very generally distributed throughout the whole of the Wenlock shales.

6. RHOPALONARIA sp.

Rhopalonaria sp., Vine. Ann. Mag. Nat. Hist., Aug., 1884, p. 86, fig. V.

The figures of this species were supplied to me by F. D. Longe, Esq., F.G.S., and I am unable to give better evidence than that which I wrote for the Annals (loc. cit.) It differs from the Wenlock shales species, and if fuller descriptions were given, or specimens forwarded to me, either a distinct species, or at least a distinct variety might be established.

Habitat: On Spirifer.

Locality: Upper Silurian beds, probably Ludlow (F. D. L.)

Related forms.—American.

Rhopalonaria venosa, Ulrich.

= Ropalonaria id, Ulrich. Jour. Cinc. Nat. Hist., vol. II., p. 26 pl. VII., figs. 24-44a.

Form and Locality: Hudson River group, Clarkville, Ohio.

Habitat: On Streptelasma corniculum, Hall.

Rhopalonaria pertenuis, Ulrich.

= Ropalonaria id, Ulrich. Report. of the Low. Silurian Bryozoa of Minnesota. 14th Annual Rept., 1886. Geol. and Nat. Hist. Survey.

"This species," says Mr. Ulrich, "is closely allied to the Stomatopora (Ropalonaria) elongata, Vine, from the English Wenlock deposit." (See Number 8.) Its relationship to R. venosa, Ulrich is still closer.

Form and Locality: Rare in the Trenton shales at Minneapolis, Minnesota.

Genus III.—STOMATOPORA, Bronn.

As restricted in Brit. Assoc. Report, Fossil Polyzoa (mihi), 1883.

For Synonyms, &c., see Busk & Hinck's.

Zoarium repent, adnate or free at the extremities, giving off erect processes (proboscina): simple or branched: branches more or less ligulate. Zoœcia in great part immersed, arranged in a single series or in several, which take a linear direction, or are very slightly divergent.

7. Stomatopora dissimiles, Vine. Pl. XII. figs. 13-16.
=Stomatopora id Vine, Quar. Jour. Geol. Soc., Nov. 1881, p. 615, figs. 1-8, p. 616.
Stomatopora id Vine, Quar. Jour. Geol. Soc., Feb. 1882, p. 50.
Habitat: on crinoid stems and broken shells.
Locality: Buildwas beds, near base of Wenlock shale.

8. Stomatopora dissimilis var. a. elongata, Vine. Pl. XII. fig. 17, Quar. Jour. Geol Soc., Feb. 1882, p. 50.
Habitat and Locality: the same.
The variety is fully described in the above paper.

9. Stomatopora dissimilis var. b. compressa, Quar. Jour. Geol. Soc., Feb. 1882, p. 51.
Habitat: on stones, corals and brachiopoda.
Locality: Wenlock limestone.

Fully described in the above paper, wherein I remark that the variety has never been found in shales below the Wenlock limestone.

Allied or distinct American Silurian forms.

Stomatopora inflata, Hall, Palæon. of New York, vol. 1 (Alecto.)
=Hippothoa inflata, Nicholson, Ann. Mag. Nat. Hist. Feb. 1875.
=Stomatopora inflata, Vine, Quar. Jour. Geol Soc., Nov. 1881.
Range: Trenton Limestone (Hall): Hudson River; Cincinnati group.

Stomatopora auloporoides, Nich. Ann. Mag. Nat. Hist as Alecto, Feb. 1875. Pl. XI. figs. 2-26.
Locality and Form: Cincinnati group, Cincinnati, Ohio.

Stomatopora frondosa = Alecto frondoso, Nicholson. Ann. Mag. Nat. Hist., Feb. 1875. Pl. XI. figs. 3-3a.
Range: Hudson River group, (Low Sil.) Cincinnati; Wanesville, Ohio.

Stomatopora confusa, Nicholson.
= Alecto id, Nich. Ann. Mag. Nat. Hist., Feb. 1878, Pl. XI., fig. 4.
Locality and Form: Cincinnati groups, Cincinnati, Ohio.

The whole of these species are very abundant in the Cincinnati rocks of America. The forms and specimens supplied to me by the kindness of Mr J. M. Nickles and also by Professor Nicholson have enabled me to study in detail the remarkable group. The

species are very prolific, and the colonial growths cover alike stems of crinoids, shells, and many of the specimens of the Bryozoons of American authors.

I have no record of Stomatopora in either the Devonian or carboniferous rocks of this country, and so far as I am acquainted with the literature of the group, I have no notes or descriptions of species from similar horizons of other countries.

Stomatopora voigtiana, King, Permian Foss., p. 31, pl. III., f. 12.
= Aulopora id., King. Permian Foss., Palæont Soc., 1850.
= Aulopora n. s., King, De Verneuil Bull. Soc. Geol. Fr. 2 series. vol. I., p. 24, 1844.
= Aulopora n. s., King, Geol. Rus., vol. I., p. 221, 1845.
= Stomatopora (Aulopora) dichotoma, Lamx, King's Cat., p. 6, 1848.

This species appears to me to be a true Stomatopora, but very little detail is afforded by the author, either in the diagnosis or figure.

Habitat: Adherent to the outer exterior of Productus horridus.

Localities and Form: Permian rocks, Humbleton quarry ("where it is rare." King.)

Some of the multiform species of Professor Nicholson would, under ordinary grouping, be placed in the sub-genus Proboscina. Mr. E. O. Ulrich places the name as a genus after Stomatopora and before his genus Berenicea, but proboscina is regarded by Hincks as belonging to the Stomatoporæ, and in his diagnosis of the genus Stomatopora he provides for the multiserial forms.

In one of my earlier papers* I endeavoured to grapple with the Palæozoic genus Berenicea, species of which had been located either as Diastopora or Berenicea, and I suggested that the B. megastoma M'Coy should be placed rather as a Ceramopora as defined by Hall (l. c. pp. 358-9), at the same time accepting Ceramopora as a member of the Diastoporidæ which I then sought to establish.

Since then great advances have been made, and had I been

* Review of the Family Diastoporidæ, Quart. Jour. Geol. Soc., Aug. 1880, pp. 356-361

aware of the wonderful richness of forms brought to light by Ulrich and others, I should not have ventured upon the placement therein suggested. In a recent paper on the Genus Fistulipora M'Coy (amend Nicholson and Foord,†) the authors, besides giving a new nomenclature for certain structural features, place the Carboniferous species referred to above, as a synonym of Fistulipora incrustans, (=Calampora id. Phillip's Geology of Yorkshire). I am obliged to accept the placement of the authors because they were able to examine the original specimen of Phillips, "now preserved in the British Museum." (l. c., p. 501.)

Family II.—Tubuliporida.

British Association Rep. Foss. Polyzoa, 1883.

Zoarium adherent, more or less free, flabellate, lobate, or cylindrical. Zoæcia tubular, disposed in contiguous series. Oœcium, an inflation of the surface of the zoarium at certain points, or a modified cell.

Genus Diastopora? Lamx.
,, Diastoporella, Vine.
,, Entalophora, Lamouroux.

It must be apparent to the student that the generic grouping of this family is undoubtedly artificial, yet under present circumstances it is impossible that it should be otherwise. The Diastopora of the palæozoic rocks are entirely unlike the Diastopora of the latter rocks, and it is very questionable whether a real affinity could be consistently established, yet it would be folly to seperate them, unless we entirely restrict the genus Berenicea* for palæozoic species alone. In his elaborate papers on American palæozoic Bryozoa, Mr. E. O. Ulrich describes two species as Berenicea:—B. primitiva Ul., and B. vesiculosa Ul.: but I cannot see from his description of either genus or species that he seeks to separate them from the mesozoic or recent forms—in other words, his idea of Berenicea is the same as that of

† Ann. Mag. Nat. Hist. Dec. 1885, pp. 496-517.

* Family Diastoporida, Vine, Quart. Journ. Geol. Soc., Aug., 1880, p. 360.

Busk, Hincks, and Waters in describing Diastopora. Under these circumstances it seems to be useless to increase the difficulties of our already too much encumbered nomenclature by furnishing two names for one group. In Diastoporella the difference between Diastopora is recognised, and as this is a well-marked Silurian genus I have endeavoured to give it prominence by a full description. The Entalophora, too, are different from later forms, but this will be pointed out when describing the palæozoic species.

The Mitoclema of Ulrich, as pointed out by the author* bears considerable resemblance to the mesozoic and recent genera Spiropora Lamx, and doubtless belongs to the same family of Bryozoa," and he seeks to establish Mitoclema because there is a difficulty in carrying over the well known Jurassic forms to make them serve as generic types for palæozoic species. Mr. Waters,† however, differs in his appreciation of Palæozoic Entalophora, for he considers that Mitoclema cinctosa, Ulrich can only be regarded as a synonym, for he thus places it in his list under Goldfuss' well known Entalophora verticillata. But my own experience goes to show that there are the same difficulties to grapple in dealing with the Palæozoic Entalophora as with the Diastopora. I cannot, however, speak with authority respecting Mitoclema cinctoso for I do not know it otherwise than by figure and description.

Genus Diastoporella, Vine.

Diastoporella, Vine. Brit. Assoc. Rep. Foss. Polyzoa III. 1883.

Zoarium encrusting, rarely circular. Zoœcia tubular, elongate, contiguous arranged in regular series; cell mouths circular, with well formed peristome, and occasionally slightly less than the diameter of the cell.

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10. Diastoporella consimilis, Lonsdale. Pl. XII., figs. 8-18.

Aulopora consimilis, Lonsdale Silurian System, p. 1567, pl. 15, fig. 7.

Reproduced as pl. xli. Siluria Ed., 1859, Marked 7 Diastopora ? consimilis, "probably a Bryozoon."

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*Journ. Cincin. Soc. Nat. Hist., Oct. 1882, p. 159.

† Quart. Journ. Geol. Soc., vol. 40, p. 685.

Diastoporella consimilis, Vine, Quart. Journ. Geol. Soc., Feb. 1882, p. 58.

Diastopora (Aulopora) consimilis, Vine, Brit. Assoc. Rep., II. 1881.

Diastopora consimilis, Vine, Quart. Journ. Geol. Soc., Feb. 1882, p. 58.

Diastoporella consimilis, Vine, Brit. Assoc. Rep. Foss, Polyzoa, IV., 1883.

Zoaria encrusting by a single layer, a fragment of coral. Zoœcia tubular, rather regular in series. As several colonies are found upon the same coral, a remarkably irregular character is given to the associated zoaria. Cell mouths circular, with well formed peristome, slightly less than the diameter of the tubes. Six zoœcia occupy the space of a line measured across the mouths of the cells, and two-and-a-half to three, lengthwise, in the same space.

Habitat: On shells, corals, etc. On Meristella tumida, Gotland (Dr. Lindstrom).

Localities and Form: Wenlock shales: Wenlock limestone. Upper Silurian, Gotland; Lower Ludlow (?) Ledbury (School of Mines Cat.) Devonian limestone, Padstow (Salter), as Berenicea M'Coyii, Salter. (Middle Devonian.)

Cabinets: My own; Mr. Longe, F.G.S., Cheltenham; School of Mines, Jermyn Street, London.

The example of this species presented to me by Dr. Lindstrom, encrusting a specimen of Meristella tumida, has enabled me to check the above description, which was diagnosed from Mr. Longe's Wenlock limestone form, both of which are far more robust than my own Wenlock shale specimen from the Buildwas beds.

This is the only species of the true tubular Diastopora type that is known to me in the Palæozoic rocks of this country. Mr. Ulrich describes, as previously stated, two species of Berenicea, only one of which I can regard as an ally of the present form.

Berenicea primitiva, Ul., Journ. Cin. Soc. Nat. Hist., Oct., 1882, p. 156, pl. VI., fig. 4.

Mr. Ulrich gives as one of the characters of this species, the following: "Cell apertures usually about twice their own diameter

distant from each other," but as his figure resembles somewhat the No. 3 of my plate, drawn from Mr. Longe's specimen, I cannot help but direct attention to the Cincinnati form, which the author says is rare.

There is another species of Berenicea described as Berenicea minnesotensis, Ulrich, which the author says is "almost exactly intermediate between the Cincinnati group, species B. primitiva, and B. vessiculosa," but no figures are given.

Form and Locality: Not uncommon in the shales of the Trenton group at Minneapolis, Minn. 14th Rept. of the Low. Silurian Bryozoa of Minnesota, E. O. Ulrich, 1886.

Genus ENTALOPHORA,* Lamx.

1821. Entalophora, Lamouroux; Waters, Hincks, etc.

1821. Spirapora, Lamouroux; Haime, Reuss, Vine for Silurian, etc.

1834 Pustulopora, Blainville; Busk.

1882. Mitoclema; Ulrich.

Zoarium erect and ramose, rising from a more or less expanded base, composed of decumbent tubes; branches cylindrical and sometimes compressed. Zoœcia tubular, and opening on all sides of the branch.

11. ENTALOPHORA REGULARIS, Vine.

= Spiropora regularis, Vine, Quart. Journ. Geol. Soc., Feb. 1882, pp. 55-56, figs. 4, 5, 6.

= Entalophora regularis, Vine, IV. Brit. Assoc. Rep. Foss. Polyzoa, 1883.

Locality and Form: Wenlock shales; Wenlock limestone; shales over Wenlock limestone.

Range: There is a species very similar to the above if not identical with it, in the Niagara Limestone of Lockport. (My own cabinet.)

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12. ENTALOPHORA INTERMEDIA, Vine.

= Spiropora intermedia, Vine, Op. cit., p. 57, figs. 7-8.

*For the purpose of placing myself in accord with workers on living Polyzoa, I adopt, at the suggestion of my friend A. W. Waters, the above name for the Spiropora described by me.

= Entalophora intermedia, Vine, IV. Brit. Assoc. Rep., Foss. Polyzoa, 1883.

Locality and Form.: Upper Wenlock—Tickwood beds,

Allies? American Palæozoic Bryozoa, Ulrich.

Mitoclema cinctosa, Ul., Journ. Cin. Soc. Nat. Hist., Oct., 1882, p. 159, pl. VI., figs. 7-7a.

Mitoclema (Gorgonia?) perantiqua, Hall, Palæon. N. Y., vol I., p. 76, 1847. (Ulrich.)

Localities and Form.: Wetherby, bottom of the Gorge Kentuchy river, near Highbridge Ky., Trenton. (Hall.)

Mr. Ulrich places the genus Mitoclema, which he defines as below, in the Fam Entalophoridæ, Reuss: "Zoarium ramose, slender. Cell mouths more or less prominent, and arranged in transverse series round the branches or irregularly spiral." (Op. cit., p. 150.) There is a difference in the American species, and because of the regularity of the spirals Mr. Waters suggests that it might probably be identical with the Mesozoic Entalophora verticilata, Gold.

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13. ENTALOPHORA ESCHARAFORMA (n. sp.? Provisional). Pl. XII. figs. 21-22.

There is present in the shales a very peculiar fossil, occasionally branching, sometimes flattened, which I place here provisionally. Fragments fit for diagnosis are rare. The cells are arranged in diagonal rows on the stem, having an eschara like character superficially, but in section the cells are regularly tubular; occasionally a colonial growth in a ribbon-like band covers the original colony, with a base similar to the band-like growths of species of Terebellaria in the great Oolite. The cells in some of the examples are not altogether unlike, superficially, the Discopora favosa* of Lonsdale.

Localities: Buildwas beds generally, occasionally in Tickwood bed. No. 42.

Family FENESTELLIDÆ (restricted.)

Zoarium forming large or small fenestrated, or non-fenestrated

* Specimen in the School of Mines.

expansions. Zoœcia arranged biserially in the branch, tubular, but slightly truncated at the distal extemity; orifice circular, opening on one side only. Branches united by dissepiments, or free. 4th Report on Fossil Polyzoa. Brit. Assoc., 1883.

Genus, FENESTELLA, Miller & Lonsdale. Type F. plebeia, M'Coy.

Genus, PTILOPORA, M'Coy. Type P. pluma M'Coy.

Genus, PINNATOPORA, Vine. Type P. elegans Y. & Y.

In founding and limiting this family, I did so on the ground of the biserial arrangement of the cells in the branch which, except in one instance, F. intermedia, Shrubsole, seems to be a persistent character.

The genera placed in this family group have one natural feature in common, there are in nearly all of them a biserial arrangement of the cells in both the branches and the pinnæ. Mr. Ulrich, however, founds his family, Fenestellidæ King, upon the fenestrate character alone. This may, however, be a sufficient plea for the grouping so far as concerns Palæozoic genera, but if a character like this is to be accepted as a relationship for family grouping, I see no valid reason for excepting the fenestrate Retepora, Adeone, or even Hornera from the Fenestellidæ. I think, therefore, that it is much better to limit the group especially on account of the cell characters.

The Fenestellæ of the Palæozoic seas form a peculiar, but at the same time a very persistent group. Beginning as far back in time as the Caradoc, species range through all seas from that horizon up to the Permian, and it seems to have been a universally distributed type.* In our British rocks, before the revision by Mr. Shrubsole, nearly thirty-five species were recorded, twenty-six alone of which were characterised by as many specific names in the Carboniferous area, and nine in the Silurian rocks. Independent however of other identifications, there are lists of no fewer than eighty-seven species in two American horizons alone—Lower Helderberg Group, Hall, (Upper Silurian), and Upper Helderberg Group, Hall, (Devonian). Mr. Ulrich describes only one species of Fenestella, remarking that F. oxfordensis, Ulrich, "is the only undoubted species known to me from

* It has been noticed even in the Carboniferous rocks of China.

American Lower Silurian rocks." In the face of this prolific catalogue it is manifestly impossible for me to attempt to co-relate British and American forms, and all that I shall do here is to give the revised list of Mr. Shrubsole, without remarks, and refer the student to his papers for special details.

14. Fenestella rigidula, M'Coy, Brit. Pal. Foss., p. 50, pl. I., fig. 19.
15. ,, reteporata, Shrubsole, Quart. Journ. Geol. Soc., May, 1880, p. 249, pl. XI., figs. 1-1c.
16. ,, lineata, Shrubsole, (l. c.) pl. XI., figs. 2-2a.
17. ,, intermedia, Shrubsole, (l. c.) p. 250, pl. XI., figs. 3-3a.

These are the whole of the Upper Silurian species accepted by the author, but if better material could be obtained, in all probability, two at least, if not three, could be added to the list. The Carboniferous list is equally poor, five species only are accepted as genuine by Mr. Shrubsole. The genus Ptilopora is peculiarly carboniferous, so also is Pinnatopora; but from certain investigations made by Mr. Shrubsole, he is inclined to admit one species at least from the Silurian rocks as a member of this latter group.

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17. PINNATOPORA SEDGWICKII, Shrubsole, Quart. Journ. Geo. Soc., May, 1884, p. 330.

= Glanconome disticha (pars.) Lonsdale, Brit. Pal. Foss., p. 49.

= Ramipora hochstetteri (Toula.) Var. carinata R. Eth., Jun. Geol., Mag 1879, p. 249.

Pinnatopora Sedgwickii Shrubs, Proc. Chester Soc. Nat. Sc., No. 3, 1885.

Loc. and Horizon: Fairly abundant in the Bala beds of Glyn Ceiriog, Denbighshire, and Bwlch-y-gaseg and Cerig Coedog, South of Corwen and Boyntirion.

Family POLYPORIDÆ.

Fam. Polyporidæ, Vine, Brit. Assoc. Rep., Foss., Polyzoa, 1883.

Zoarium forming large and small fenestrated expansions. Zoœcia contiguous: with three rows and upwards of cell-openings in a row, on one side only. Branches united by dissepiments or by anastomosis.

Genus Polypora, M'Coy. Type P. dendroidea M'Coy.

Genus Phyllopora, King. Type P. ehrenbergii, Geinitz.

The genus Polypora, so far as I am aware, is not represented in British Silurian rocks, otherwise than by the species P. problematica, and I have no record of the genus having representatives in the Silurian rocks of other countries. Our first acquaintance with Phyllopora is, as a new genus, founded for very peculiar Permian fossils. When compiling my Brit. Assoc. Report, 1881, I was allowed to examine the whole of the type species of the so called Retepora in the School of Mines, and I was unable to accept this genus for any of the Silurian Polyzoa, and the next best association for the group was in the genus Phyllopora, as founded by King. I accepted the term, however, not without compunctions, because two good workers, Salter and De Koninck, had consecrated the genus for other than Permian fossils. It is impossible, judging from King's figures alone (Perm. Foss. pl. v. figs. 1-6) to recognise the P. Ehrenbergi, as of the same character as the Silurian fossils which bear, or may bear, the same generic term, but the author must be credited with a desire to establish the genus both for Permian and Silurian species. "I suspect that Phyllopora will eventually embrace several species of Palæozoic corals, &c." (Op. cit., p 42.) With this knowledge in hand, Mr. Shrubsole, when re-examining the types as well as other Permian Polyzoa preserved in the Newcastle Museum, assented to King's judgment, by adopting Phyllopora both for the Permian as well as the Silurian species. (Quart. Journ. Geol. Soc., Aug. 1882, pp. 347-349.) Since then Mr. E. O. Ulrich (14th Ann. Rep. Bryozoa of Minnesota, p. 63, 1886, in his remarks on a new species, Phyllopora ? corticosa—has offered the suggestion that in all probability King's species may be allied to Polypora M'Coy and Lyropora Hall, and " should that be the case, then it would be necessary to establish a new genus for the reception of the species " cited by him, such as Intricaria, Hall, and Retepori trentonensis, Nicholson, &c., which were suggestively placed by me among the Phylloporæ, (See notes on species of Phyllopora and Thamniscus from the lower Sil. rocks, Quart. Journ. Geol. Soc., May, 1885.)

18. PHYLLOPORA TUMIDA, Vine. Quart. Journ. Geol. Soc. May, 1885. p. 109, woodcut.

Horizon and Locality: Caradoc beds: Wern-y-seadog, Llanfyllin.

Range of variation: Under present circumstances and without having the lower Silurian fossils by me for examination, it will be useless to make any further remarks on this point. It is much to be desired that existing material in private cabinets should be submitted to competent authorities for examination and description, for I believe that much good material is stowed too carefully away.

19. POLYPORA ? PROBLEMATICA, Vine. Pl. XII., figs. 23-24.

=Polypora ? problematica, Vine, Quart. Journ. Geol. Soc., Feb. 1882, p. 62.

I am unable to add further to the description of this species as given above, but I have satisfied myself that the tpye is peculiarly a Silurian one, and I have not as yet seen any American species with which it can be associated.

Localities: Buildwas and Tickwood beds.

Family THAMNISCIDÆ.

Thamniscidæ, Vine, 4th Brit. Assoc. Rep., Foss. Polyzoa, 1883.

Zoarium forming free dichotomising branches or pinnated fronds. Zoæcia on one side only, with from three to five (or more ?) rows of cell openings in a branch, occasionally having a smaller opening above or below the peristome of the cell.

Genus THAMNISCUS, King.

20. THAMNISCUS CRASSUS Lonsdale's sp.

= ? Hornera crassa, Lon. Sil. Syst., p. 677, pl. 15, figs. 13-13a.

= ? Polypora crassa, Siluria, p. 215, Foss. Figs. 35, No. 1.

,, crassa, Morris Catalogue.

= Ceriopora, Salter, Cat. Camb. Foss. p. 100.

= Hornera? crassa, Vine, Quart. Journ. Geol. Soc., vol. XXXVIII. p. 60, figs 9-10.

Horizon and Localities; Wenlock shales; Wenlock limestone.

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21. THAMNISCUS DELICATULA, Vine.

= delicatula, Vine, Quart. Journ. Geol. Soc., vol. XXXVIII., p. 61.

Horizon and Locality: Basement beds of Buildwas beds. Harley No. 22.

22. THAMNISCUS ANTIQUAS, Vine.

= Ibid, Quart. Journ. Geol. Soc., May, 1885, p. 111, figs. 2-a-b-c-d

Formation: Imbedded in volcanic ash, probably of the age of the Bala rocks.

Locality: Middleton Hall, Welshpool.

Several species of Thamniscus are described by James Hall in his corals and bryozoons, Albany, 1880, from the Lower Helderberg group, but in the absence of plates I cannot identify them by the descriptive text.

Thamniscus	variolata, Hall, p. 37,	32nd Annual	Rept.	Albany, 1880.
,,	nysa and var., Hall.	,,	,,	,,
,,	fruticella, Hall, p. 38,	,,	,,	,,
,,	cisseis, Hall,	,,	,,	,,

All from the Lower Helderberg group near Clarksville, N.Y.

CERIPORA, GOLDFUSS.
Palæont. Germ., 1826.

The genus Ceriopora, as originally founded by Goldfuss, has been so broken in upon by authors, that it appears to be impossible to accept it as sufficiently satisfactory in the present day. The Messrs. Young in their paper on Rhabdomeson (Ann. Mag. Nat. Hist., May, 1874, pp. 335-339) gave a fair review of Goldfuss's genus, and since then Prof. H. A. Nicholson has said, "Ceriopora itself is an illdefined genus, the limits and range of which are not known, forms of very diverse affinities having been included by palæontologists under the name. It is possible, however, that in the reconstruction of this genus, certain of the Palæozoic Polyzoa may be found capable of inclusion in it, as a more than merely provisional arrangement."*

The remarks of Professor Nicholson are just, and that for the very simple reason, that though we may have a difficulty in defining Ceriopora Goldfuss, there is but little difficulty, with ordinary care, in recognising or identifying the Dudley species of Ceriopora such

* Manual of Palæontology, vol. I., 1879, p. 432.

as affinis, punctata, and granulosa, though there is a difficulty in identifying C. oculata. Then again another question arises in the mind of the systematist—are these really Polyzoa? If we say yes, then there are other species that are placed by one palæontologist with the Cœlenterata, and by another with the Bryozoa, such as Cænites, Millepora or Alveolites? repens, Discopora (Lonsdale), and even Monticulipora Petropolitana Pander.*

As examples of most of these species are present in the shale washings, together with others apparently or really allied to them, it would be unwise on my part, in spite of the difficulties referred to above, to leave them out entirely. These, however, with other undescribed species will form the subject matter of another paper.

Description of Plate.

Fig. 1. Crinoid stem enlarged about 2 diams., to fragments of which both Ascodictyæ, Rhopalonaria and Stomatopora are generally attached.

Fig. 2. Ascodictya filiforme Vine, with vesicles attached, but not in clusters.

Fig. 3. A peculiar example of A. filiforme, with both root like processes and vesicle.

Fig. 4. Transparent section of another example of A. filiforme, showing centrally dotted and continuous pulp-like pith, which is connected with the vesicles.

Fig. 5. A radiciforme, Vine.

Fig. 6. A stellatum, Nich and Eth. var. siluriense, Vine.

Fig. 7. A curious example of A. radiciforme, not common, but having peculiar features which seem to ally the form of S. elongata through Rhopalonaria.

Fig. 8. One of the punctured forks of A. radiciforme which can be identified as related to forms previously described by Prof. Nich. and R. Eth. jun. (See Ann. Mag. Nat. Hist, June, 1877, pp. 463-468.)

Figs. 9 and 10. Fragments also foraminated, but from both these specimens the original material has been rubbed off, and the

* Discopora favosa, Lonsdale, &c. (See also Lindstrom's Cat. of Fossils, 1885.)

illustrations represent the foraminated basal portions. Fig. 8 represents the normal branch.

Fig. 11 Rhopalonaria botellis Vine, typical example. I have this form both with calcareous coverings and with cast like excrements without the coverings. Without opportunities of studying both features it would be difficult to found a type.

Fig 12. R. botellis, but with double features. It is through a type like this that one may trace resemblance to Stomatopora elongata, but the openings indicated in some of the cells are not cell mouths, but the dark brown mass, whatever it may be, exposed through the broken calcereous cover previously referred to.

Figs. 13 to 16. Stomatopora dissimilis, Vine. Fig. 13, about natural size adherent to crinoid stem. Fig. 14 enlarged, showing regular Stomatopora features with circular (normal) cell mouths. Fig. 15 showing one cell with a flattened lower lip; and fig. 16 with a slightly wrinkled, not exactly ribbed cell, with a peculiar orifice, probably an ovacell.

Fig. 17. Typical Stomatopora elongata, Vine.

Fig. 18. Coral covered with encrusting Diastoporella consimilis about natural size.

Fig. 19. Portion shewing where two colonial growths meet at the edge—colonies originating from different centres.

Fig. 20. Enlarged typical cells of D. consimilis.

Fig. 21. Characteristic features of the more typical Entalophora escharaforma, Vine. This is drawn from a chalky covered fragment, which are rather rare in the shales.

Fig. 22. Specimen showing double features, but without any chalky covering. In specimens we meet with cells similar to No. 21, and in other parts of the same no escharaform features are seen, but isolated openings, which may probably ally the form with some specimens identified as Ceriopora occulata, Gold. In sections the cells are tubular without tabulæ. Internal parts of the branches occasionally hollow.

Figs. 23-24. Polypora? problematica, Vine. This peculiar fossil is found rather frequently in the shale washings, both free branching and with the branches inosculated, but the cell openings

are similarly characteristic. Fig. 24 shows the reverse aspect, which is entirely without cells and coarsely striated.

ON THE RELATIVE AGE OF THE REMAINS OF MAN IN YORKSHIRE.

BY JAMES W. DAVIS, F.S.A.

It is proposed to give some account of the evidences of the presence of man in Yorkshire, and so far as possible to collate those evidences and ascertain their relative sequence. There was a people who inhabited the Yorkshire Wolds, erected defences against neighbouring or more distant foes on their summits, and buried their dead in rude graves dug in the surface of the ground, after burial they erected above them mounds of earth and stones, named tumuli, and which occur in considerable numbers scattered over the East Riding. A branch of the same tribe, or by whatever term we may choose to designate those people, occupied rude structures built on the trunks of trees, laid horizontally one above the other, in the lakes and meres of Holderness, very similar to the lake dwellings found in Ireland and Scotland. The latter appear to have been a peaceably disposed people, given to agricultural pursuits, protecting themselves from the chill east winds which swept over the North Sea, as best they could, with the skins of the animals they killed for food; tolerably safe from the attacks of the wild animals, which ranged in the neighbouring woods, when in their habitations over the water; and retreating to entrenched strongholds on the approach of human but more dangerous foes. The men of this age were acquainted with the use of pottery, which they shaped into rude vessels by hand, without the use of a potter's wheel, and decorated by making incisions either with the finger nails, or some sharply pointed instrument. Their implements for offensive and defensive purposes were made from the nodules of flint, which occur abundantly in the neighbouring chalk, chipped into the form of arrowhead, spearhead, or such other objects as they had skill to make, or comprehension to use. The antlers of the reindeer and the humerus of the ox, broken diagonally, served the

tiller of the soil as hoe and plough; and the harder bones of animals were scraped and carved into the form of pins and other implements of personal adornment or use.

Probably about the same period, or perhaps at an earlier one, the caves which abound in the mountain limestone districts of Craven, and the dales of the North Riding, afforded shelter to a primitive people, of whom we know little except that they derived a precarious existence from the chase; alternating their occupation of the caves with the cave variety of the spotted hyæna, sometimes one and sometimes the other being able to assert posession, as evidenced by the layers of bones, gnawed and broken by the hyæna, mixed with its coprolites, alternating with the flint implements and other traces of man's occupation. There is some valuable information also obtained, of the presence of man at a remote period, from the occurrence of flint flakes and implements beneath the peat on the range of hills forming the Penine chain. These have been found on the surface of the ground at the base of the peat, often ten or twelve feet in thickness. On the same horizon are the roots and trunks of great trees, which grew and flourished either before the peat gained a footing, or during its accumulation. The great trees, which almost universally flourished over the highlands, now capable of supporting only heather and grass, probably indicate a climate much warmer and milder than the one at present existing. The sheltered and steep hill sides of the valleys are now almost universally covered with trees which appear indigenous, whilst the tops of the hills, formed of the several beds of the millstone grit, are devoid of such growth; and it is difficult to imagine great trees growing luxuriantly on the storm-stripped heights of these hills.

Approaching more recent times, and removing our base of observation to the south-east extremity of the county, there are a large number of filled-up hollows scattered over the low-lying tracts of land from which Spurn Point extends. Sections of these hollows have been repeatedly exposed on the coast by the action of the waves, and there can be no doubt that they extend far inland, but, being filled-up to the level of the country and covered by soil, they are not distinguishable. They extend in all directions, without any definite arrangement,

and various sections exposed by the wear and tear and washing away of the coast line, have shown them to be about thirty yards in length, six to ten feet in breadth, and about five or six feet deep. The bottom and sides, more or less circular in outline, are distinctly marked by a layer of oyster shells, and these shells, along with those of buccinum or whelk, all more or less fractured to obtain the shell-fish, are frequent throughout the mass. In addition, fragments of pottery, large numbers of bones, and occasional ornaments in bronze are found mixed heterogeneously in a soft brown loam. These are the relics of a people, existing probably in miserable cabins near the coast, and living on shell-fish, together with the flesh of domestic animals, and possibly such agricultural produce as they could derive from the soil. The refuse of these people was thrown into pits or hollows, dug in the soft soil, and form the aggregations now remaining, without which we should have had no knowledge of them. They resemble very much the Danish Kjökkenmöddings, or kitchen-middens, whose investigation has thrown a flood of light on the early history of the people of Denmark.

In the uppermost layer of cave-earth, in the Victoria Cave, near Settle, beneath only two feet of broken fragments of limestone, there is evidence of a comparatively recent occupation of the cave, by men possessed of considerable refinements as compared with those of earlier times, already mentioned. Mixed with quantities of charcoal and charred substances, are bones of domestic animals, together with a small proportion of animals secured by hunting; bronze implements and ornaments of great beauty, along with silver and bronze coins, impressed with the heads and names of Roman emperors have been found. This last occupation of the cave appears to have been of a more or less temporary nature, and indicates, probably, the presence of refugees from the advancing armies of the continental hordes, who invaded Britain shortly after the exodus of the Romans.

Having briefly summarized some of the evidence of man's existence in Yorkshire during the long ages prior to the advent of the Roman legions under Julius Cæsar, it may be well to retrace our steps, and, after briefly considering the effects and influence of Roman civilization, to describe somewhat in detail the most prominent works

by which alone we are enabled to glean even a meagre idea of the habits and character of the primitive inhabitants of our great county. The Romans invaded Britain in the year 55 B.C., and held military sway over it until the year A.D. 409. The spread of refinement and the arts followed closely on the success of the Roman arms, and bore fruit in the adoption of her civilization by the British people. Roman stations or cities sprang up in all parts of the country, amongst the foremost of which was Eboracum, now York. It was in this city that the Romans fixed their seat of Government, and radiating from it the Roman roads proceeded north, east, south, and west, affording easy communication with neighbouring cities. The aboriginal population clustered round these cities, and were greatly improved by the contact with the conquerors. Agriculture became of great importance, and was carried out to such an extent that Britain became one of the principal corn producing countries of the Roman empire. The mineral resources of the country were explored and greatly extended. Tin was obtained in Cornwall, as it had been to a small extent for ages before; lead was got in Derbyshire, and iron in Northumberland and the West Riding of Yorkshire. Material prosperity was succeeded by luxury and culture, and numerous villas were located throughout the province, especially in the proximity of the great roads. Many of these have been excavated, and astonish us by their arrangements and the beauty of the objects enshrined in them. The Celtic inhabitants of Yorkshire fell in for a full share of all these good things, and appear to have enjoyed to the full the general prosperity of the country. The relationship existing between them and their conquerors may perhaps be best expressed by the relative position of the Hindoos to the English in India at the present time. Latin was spoken by the higher classes in the cities; in the country Celtic maintained its place amongst the original inhabitants. Christianity was promulgated and accepted, and courts of law established. But unfortunately, as so often happens, beneath all this elaborately complex system, there were causes at work which led to the decay and ruin of the district. The Romans were constantly subject to raids by the Picts and Scots, dwelling north of the Tweed. To prevent their incursions the Romans built great walls and forts, extending from the Solway Frith to the

Tyne, and from the Frith of Forth to the Clyde, but even with the aid of these they could not subdue their enemy, and the Emperor Septimus Severus died broken hearted at York, bequeathing to his son Caracalla the task of utterly annihilating the Picts and Scots. The latter, however, soon found that he had something else to do, and dissentions in Rome speedily led him to leave this country to make secure his succession to the throne. The Roman garrisons were withdrawn from Britain, as already stated, A.D. 409, and the Celts, untrained in the arts of war, soon became a prey to their enemies. The Picks and Scots descended in greater force than ever, and a most pitiable state of things resulted. In the "Monumenta Historica Britannia," one of the Rolls publications, a graphic description is given of the lamentable result to which the natives were reduced. They forsook their homes and took shelter in the mountains and forests and in caves. Ere four decades had elapsed Hengist and his warriors invaded the country and founded the first English colony. There was a steady advent of Angles, Saxons, Jutes, and Frisians, and the whole eastern coast of the country was taken possession of. The Anglians entered the Humber and founded the kingdom of Deira which is co-extensive with our modern Yorkshire, and the Celtic Brit-Welsh people, as their invaders styled them, were driven to the fastnesses of Cumberland and Wales.

The Celtic or Brit-Welsh being driven from their homes, fled with such articles of value and usefulness as they could carry with them to the more remote and inaccessible parts of the country, and it is highly probable that some of them took refuge in the Victoria and other mountain limestone caves. The Victoria Cave, so named because it happened to be discovered on the coronation day of Queen Victoria by Mr. Jackson of Settle, is situated about a couple of miles from that town and extends horizontally for a considerable distance into the precipitous side of King's Scar, at a height of 1450 feet above the level of the sea. It is a wild, mountainous and desolate spot, with a long ravine-like valley extending in front of the mouth of the cave. The slope of the valley, extending some distance up the sides of the scar, is composed of glacial clays, deposited when the valley was filled with a spur of the Great Glacier descending Ribblesdale, which

Mr. Tiddeman has estimated to have had a thickness of 700 or 800 feet. Mixed with the clay or till are huge masses of Silurian grit, marked and scratched by their passage from distant localities whilst embedded in the ice. Isolated boulders of the same rocks, similarly scratched, may be seen scattered here and there on the surface of the valley. Covering the bank of glacial clays there is a great thickness of fragments of limestone which have been detached from the cliffs above, technically denominated "Screes." At the summit of these screes, one hundred feet above the bottom of the valley, and at the base of a huge overhanging cliff is the entrance to the cave. It consists of three large irregular chambers which were filled with debris almost to the roof when Mr. Jackson followed his dog through a small opening into the cave. He was rewarded by discovering a number of Roman coins, along with ornaments and implements in bronze, in the earth on the surface. Some of the ornaments were of singular beauty; the bronze base was enamelled in bright colours with great taste. Brooches, rings, and fibulæ were discovered, which are termed by Mr. Franks, of the British Museum, to be "late Celtic," and of British manufacture. Indeed it appears more than probable that the centre of manufacture of these beautiful articles which were spread over the surface of the then civilized world, was located in Yorkshire. Philostratus, a Greek who was attached to the court of Julia Domna, the wife of the Emperor Severus, writes, "it is said that the barbarians living in or by the ocean, pour these colours on heated bronze, that these adhere, grow as hard as stone, and preserve the designs that are made in them." Mr. Franks is of opinion that this passage refers to Britain, and if such be the case, it is a reasonable assumption that the seat of manufacture would be near that of the Emperor's court at York.

The coins, about twelve in number, date from the reign of Trajan, A.D. 117, to that of Constans, A.D. 353, and there were also some imitations of bronze coins, which are about A.D. 400-500. In addition to the coins and bronze objects, a large number of bones of animals, which had been used for food, and some bone implements used as pins, spindle whorls, and other objects were found. The number of bones of the Celtic short-horns, similar to the cattle of Scotland and

Wales of the present day, proved that it was the chief food of the occupants. The bones of goat, pig, and horse were frequently met with. The horse was a common article of food in this country until the ninth century. Bones of the roedeer and stag, fowl, wild duck, and grouse, complete the list. Bones of the dog were found, but had not been used for food, as the animal was in earlier times. The people who occupied the cave at this period were evidently possessed of considerable intelligence, acquainted with some arts, were accompanied by women and children, and lived upon their flocks and herds, occasionally supplemented by animals caught in the chase. It is highly probable that the date of their occupation immediately follows the exodus of the Romans from this country.

In addition to these objects dug up not deeper than two feet from the surface, others were found at considerably lower depths, beneath broken limestone screes, clay, and stalagmite, compared with the antiquity of which the remains already mentioned are but as yesterday. Prof. Boyd Dawkins says, "It was inhabited by man in the neolithic age, at a time so remote that the interval between it and the historical period can only be measured by the rude method by which geologists estimate the relative ages of the rocks." From this lower stratum were obtained the bones of the brown bear, stag, horse, ox, a bone harpoon, a carved bone bead, and some flint implements, indicating the occupation of the cave by a much ruder set of people than the Romano-Celtic, who existed on animals obtained in the chase, and fish caught in the neighbouring Tarn at Malham. Below this stratum is a thick bed of cave-earth, a stiff clay, probably deposited by water, with angular fragments of limestone; in this skulls, jaws, and bones of the spotted hyæna are abundant, together with others of the woolly rhinoceros, mammoth, bison, reindeer, horse, and three species of bear. The bones are all more or less broken and gnawed by the hyænas. The most remarkable discovery was a part of a fibula, considered to be that of a man, in close association with the bones of the animals named, which, if correct, proves that man was contemporary with the cave hyæna and the other pleistocene mammals found in the cave.

The Victoria Cave is given as a typical example of many others which exist, and have been explored in Yorkshire. The animals of the lower stratum are the same as those found in Kirkdale Cave, explored by Dr. Buckland, and in the Raygill Fissure, in Lothersdale, which has been investigated on behalf of the Yorkshire Geological and Polytechnic Society, during the past two or three years. At Leeds, also in the river gravels, similar animals have been found, and in addition to those named, the teeth and bones of the hippopotamus have been discovered. It ought also to be mentioned that the Raygill Fissure has afforded an example of the tooth of the lion. It would be interesting to give a detailed account of this fissure and its contents, but it is unncessary to do more than call to mind a period in the remote past, when Yorkshire possessed a much more genial climate than it has at present, which rendered possible the existence of animals, many of which are denizens of tropical regions. If man existed here in those times his ears would be familiar with the roar of the lion and the heavy tramp of the elephant, Hippopotami disported themselves in the Wharfe, the Aire, and the Calder, on the banks of which the rhinoceros, the bison and the deer, with many other animals of smaller size, left impressions of their frequent visits. Whilst away, skulking behind the rocks in the hills, the hyæna prowled in search of prey.

Turning now to the East Riding, the surface of which is largely formed of the chalk Wolds; hills rising to a height of 400 to 800 feet above the sea level with ramifying vallies interspersed, through which, however, no stream runs, the rain being absorbed by the chalk, like a sponge, and carried to the sea by underground percolation. On the wolds there are numerous evidences of an early people about whom there is no historical record. On the surface of this country the plough has turned up innumerable objects made from flint; arrow heads, points of spears, implements used for pounding corn, others apparently, used in dressing hides, hammers, knives, pointed tools, pot-boilers, and many others. These have, undoubtedly, been fashioned by the hand of man; but of themselves they do not afford a very perfect idea of the style of individual that man was. Fortunately, there is other evidence. All through the district there

are hundreds of raised mounds, some of an elongated form, others more or less round. A large number of these have been opened by Canon Greenwell, and also by Mr. Mortimer, of Driffield. They have been found to contain human skeletons, and with them, objects buried with the body, which, like the North American Indians of to-day, the sorrowing relatives supposed would be of service to the dead in a future state of existence. In the long mounds or barrows, as they are termed, the skeletons as well as the objects found with them are very different to those found in the round ones. The builder of the long barrow was a man with a long head, much longer from back to front than broad; whilst the round barrows contain bodies with round heads, in which the breadth equals or exceeds the length. In the round barrows implements of bronze, ornaments of bone and jet, and pottery of varied forms have been discovered; whilst the long barrows contain no bronze, but only impliments of flint, similar in all respects to those already enumerated as having been found on the surface; the pottery associated with the flints is of a ruder character, quite distinct from that of the round barrows. Whilst some of the round barrows contain only round skulls, others are more or less mixed with those of the earlier long-headed people, leading to the inference that the latter, first in possession of the soil, were overrun by the roundheads, and that a gradual amalgamation of the two tribes then took place, but that eventually the long-headed people succumbed to their conquerors, and were gradually exterminated or died out. Canon Greenwell says* "When we come to consider the characteristics of these two distinct peoples, we observe at once a wide difference in their appearance. The long-headed one does not appear to have been either so tall or so strongly made as the other. The average height of the first may be taken to be about 5 feet 6 inches; that of the other as about an inch more. The dolicho-cephalic (long-headed) people were also of a somewhat softer outline, in all the features of the head and face, than the more rugged brachy-cephalic (round-headed) people. The cheek bones are by no means prominent, nor, as a rule, are the supraciliary ridges so much or so early developed as in the round-headed skull, both of

* British Barrows, 1877, p. 127.

which would make the face soft in its expression. The forehead is of an average heighth and breadth, rather higher than broad however in its general proportions. The head is long, as indeed the term applied to it implies, and has the parietal bosses quite rounded off. The occiptal region of the skull is prolonged in a marked degree, and adds much to the lengthened appearance of the head. Taken as a whole, it may be said that regularity and smoothness of outline is the main characteristic; and that those prominences are wanting which must have given such a harshness of feature to the brachy-cephalic head. The latter differs, in almost every particular, from that just described. The lower jaw is massive, and in a certain degree square at the chin. The malar bones are prominent; and the supraciliary ridges strongly and early marked: thus affording in the rugged and fierce expression which the face must have presented, a strong contrast to the pleasing appearance of the other people. The forehead is broad though not low. The head is remarkably short and square. The occiput is so much flattened as to have suggested to some that it is due to an artificial process, such as the habit of placing the infant with its head resting at the back against a board or some other contrivance; or to the child having been carried for long during the period of infancy. The skull of both types is capacious and the different parts are well balanced; nor is there anything in it to lead to the belief that either people was wanting in mental power."

The long-headed people where the earliest of which there is any kind of record known at present. They lived peaceably; followed agricultural pursuits, and had herds of oxen and other domesticated animals. They were probably existing at the same time as the earlier inhabitants of the caves to the west. They appear to have had social communities, and were regulated by some kind of laws; had chiefs whom they recognised as leaders, but altogether lived a quiet and sedentary life. Their peace was interrupted, perhaps destroyed, by the advent of the roundheads, who may have come across the North Sea, but of whose origin we have no distinct information. There appears every probability, however, that they were a warlike people, and that they were the builders of the entrenchments commencing with the Danes'-dyke across Flambro' Head, and extending

and ramifying over almost every hill on the Wolds. A great number of these entrenchments, large and continuous mounds of earth, with a moat-like hollow on the inside, have been mapped and investigated superficially, and exhibit a marvellous series of defensive or offensive earthworks, indicating not only a large population, but persistent and united action on the part of its members.

The new comers were possessed of a higher civilization than the people they supplanted. They were acquainted with the use of bronze, their pottery was of a higher character, and they decorated themselves with necklets of jet. Women have been disinterred whose bodies were buried with rings on the fingers and beads round the neck. They cultivated the ground, and had domestic cattle, as their predecessors had. They were not possessed of wealth, and their intercourse, in the way of traffic with people at a distance, must have been very limited. The discovery of woollen and linen fabrics in the graves prove that they were acquainted with the manufacture of those goods, and spindle whorls have also been found. Altogether they were a people possessed of much more refinement than their predecessors, and may be regarded as the heralds of that greater advance which was to follow on the advent of the Romans some hundreds of years later.

A large proportion of the graves contain bodies which were cremated before burial. In others the bodies are simply inhumed. The usual method in the latter case was to dig a hole to a greater or less depth beneath the surface, and place the body in it in a contracted position, with the knees drawn up towards the chin. If a male, the body is laid generally on the left side, and if a female, on the right. It was then covered with earth, and a mound raised above it. When the body was cremated, the ashes are sometimes placed in an urn which, with any other objects, was placed in the grave and covered up by a mound. Canon Greenwell is of opinion that the process of burning the body was part of the ceremony or ritual of the burial, because in many instances fire has been applied but the burning has only been partial, and the bodies are buried without urns. The number of burials in a mound, and the size of the mound, appears to have depended on the importance of the individual; and at the

burial of persons of high rank or standing there is evidence that a custom prevailed, which existed until recent times amongst the Hindoos, of killing at the funeral, and burying with the man, wives, children or others. The frequent discovery of several bodies, all certainly interred at the same time, or of two persons of different sexes, with the remains of children, are incidents difficult to account for in any other way.

As to the age of the round-headed people only an approximate idea can be formed. They introduced bronze implements into the Wold district, but they do not appear to have had any knowledge of iron. The latter metal was known to the people whom Julius Cæsar found occupying the country, and was probably known for two or three centuries previously. We shall be quite safe, therefore, in fixing the age of the more recent named builders earlier than the advent of the Romans, aud it is very likely that 1000 to 500 B.C. will be rather within the mark than beyond it.

The lake dwellings at Ulrome, seven miles south of Bridlington, have a peculiar interest to the archæologist. They are the first of the kind discovered in England, and Dr. Monro is of opinion that some portion of them are of a much older date than the Scotch crannoges, which are somewhat similar in construction. Holderness is to a large extent artificially drained; the water is run through drains into the sea at low water, and when the tide rises it is prevented by sluices from re-entering the drains. Scattered over the district there are numerous remains of ancient lakes and peat bogs, and there is no doubt that at one time the whole of the district was in a great part under water. It was during that time that the structures were erected that gave support to the lake dwellings. One of these was discovered by Mr. Boynton, of Ulrome Grange, and has been most carefully investigated by him. The structure was erected on the edge of a lake, its base being about ten feet beneath the present level of the ground. Large tree trunks, about twenty feet in length and eighteen inches in diameter were laid horizontally at the bottom, and secured by rudely pointed stakes driven into the bed of the lake on each side the trunk; between these parallel timbers others were placed transversely, the whole being connected together by wood stakes until a

a platform was erected, covering an area of seventy-five feet by fifty feet, and connected by a bridge or gangway, with the rising ground towards the east. The interstices between the timbers were filled with branches and twigs of trees until a level surface was obtained; upon the solid surface thus obtained there was placed about eighteen inches of smaller twigs and bark, and on this erection, probably reaching a short height above the water were erected the dwellings of the builders. In process of time the timbers appear to have become to a large extent rotten, and there is a second platform erected on the first. It is similar in construction, held together by pointed stakes, but in latter structure the points of the stakes are much longer, and have evidently been cut by a sharper instrument. The top of the second platform is three feet below the present surface of the ground. During the excavation many interesting objects have been found. On the lower platform they consisted of stone and bone implements; rounded stones for pounding grain; pointed or sharpened stones pierced with a hole, and used as hammers or adzes; flint flakes, used as knives and for other purposes, are common. The bone implements are mostly large and of rude form, some of them of a type previously unknown. The large leg bone of the ox is broken diagonally across, and a hole bored in the upper part through which a stick can be placed, forming a gouge-like instrument, probably used as hoes for tilling the ground. The antlers of deer have been used for the same purpose. Pieces of pottery of an early British type occur. In addition to the bones of the animals already named, there have been found the jaws of wolves, tusks of wild boar, head of horse, and red-deer; bones of sheep, dog, and smaller animals, as well as the bones of birds, probably geese. All these have been found in the interstices amongt the twigs and bark on which the dwellings of the earlier occupiers were erected. In the upper part, above the second platform, a fine bronze spear-head has been found. It appears, from a consideration of these objects, that the second platform may have been the habitation of families of men of the same period as the round-headed, bronze-using people who built the barrows some miles to the northwards; whilst the original constructors of the older platform, who had no knowledge of bronze, but used only flint and bone implements, were of the older type

with long heads. The remains of the people hitherto found indicate that they were of a peaceable character, following agricultural pursuits; the bone hoes would be well suited for working up the light loamy soils on the higher ground bordering the lake. The dwellings were erected over the water, in all probability as a protection against wild animals, rather than against human foes.

Such are the remains feft for consideration by the primeval inhabitants of our county. Much remains unsaid in this brief account of them, but sufficient has been brought forward to prove the vast interest of the subject; to afford subjects for contemplation by the thoughtful mind; and to exercise the imagination not only of scientists bnt of all who take any interest in their earliest ancestry. Whilst the Assyrians and the Egyptians were in the height of their civilization, the people in this country were neither more nor less than a race of savages. The culture and refinement of the Assyrians and Egyptians has departed from them, and their descendants have become degenerate; meanwhile the English have reached the highest stage of civilized developement hitherto attained by man. Such are the constant changes in human progress.

ABNORMAL BAROMETRICAL DISTURBANCES IN YORKSHIRE, IN 1883 AND 1884. BY RICHARD REYNOLDS, ESQ., F.C.S.

1883.

ERUPTION OF KRAKATOA.

The Proceedings of the Royal Society, vol. 36, p. 139, contain the report of a paper read before the Society, Dec. 13, 1883, entitled "Note on a Series of Barometrical Disturbances, which passed over Europe between the 27th and the 31st August, 1883. By Robt. H. Scott, F.R.S., Secretary to the Meteorological Council."

Shortly after the publication of the above paper, Prof. T. E. Thorpe, F.R.S., then Professor of Chemistry in the Yorkshire College, Leeds, wrote to the "Leeds Mercury" the following account of the

influence of the Krakatoa Eruption, in the Straits of Sunda, upon barometrical records in Europe, including observations in Leeds.

"The last issue of the Proceedings of the Royal Society contains a remarkable paper, by Mr. R. H. Scott, F.R.S., the Secretary of the Meteorological Council, on a series of barometrical disturbances which passed over Europe between the 27th and the 31st August, 1883."

"It appears that when the barograms obtained from some sixteen observatories situated in various parts of Europe, from St. Petersburg in the east, to Valentia off the Irish coast, in the west, are compared together, the curves extending from about noon on the 27th to the end of the month are seen to exhibit a series of remarkably sudden depressions and quick recoveries of pressure. These disturbances were not actually synchronous at the various observatories. At about 11 a.m. (Greenwich time) on the 27th there was a sudden increase of pressure, followed by a decrease, at St. Petersburg; similar phenomena were noticed, but not precisely at the same time, at Brussels, Paris, Kew, Aberdeen, Liverpool, Armagh, Coimbra, and Valentia, besides a number of intermediate stations. The movement at about this time was in fact being propagated from east to west at a very great velocity; the recovery from the first decrease occurred at St. Petersburg at noon, and at Valentia Island at 2.25 p.m. that is, the movement occupied two hours twenty-five minutes travelling the distance of 1,315 miles between the two stations."

"On the 28th a similar disturbance was propagated from west to east; it was at Valentia at 3.20 a.m., and at St. Petersburg at 5.15 a.m., the passage occupying one hour and fifty-five minutes.

"On the 29th a return wave reached St. Petersburg at 0 hour 20 min. a.m., and Valentia at 2 hours 38 min. a.m. Interval, 2 hours 8 min."

"On the afternoon of the 29th a disturbance from west to east occurred at Valentia at 2 hours 0 min. p.m., and reached St. Petersburg at 3 hours 35 min. p.m., thus traversing the distance in 1 hour 35 min. The disturbances became gradually feebler in intensity, and at the end of the month were no longer to be recognised."

"On the 27th of August occurred the violent volcanic outburst in the Straits of Sunda, by which in the course of a few hours the

greater part of the island of Krakatoa was literally blown to pieces; the shocks continued at least from 9 a.m. to 10 p.m., Greenwich time. The connection between the great eruption and these atmospheric disturbances is suggested in Mr. Scott's paper, and has been distinctly traced by General Strachey. General Strachey's reasoning was as follows:—Any shock of sufficient violence might be expected to produce an atmospheric wave, advancing from the place where it was caused in a circular form round the globe, at first expanding until it had got half round the earth, and then again contracting till it was again concentrated at the antipodes of the place whence it came, from which again it would be thrown back, and so pass backwards and forwards till it was obliterated. It might also have been expected that such a wave would travel with the velocity of sound, being probably of the same nature as that which causes sound, though the vibrations had not the peculiar character that affects our organs of hearing."

"It remains to be shown how the phenomena may be explained by the passage round the earth of a series of air-waves travelling at the rate of about 700 miles an hour in opposite directions from the seat of the volcanic eruption. From the known distances of the various observatories from Krakatoa, and from the times corresponding to certain sufficiently well-defined points in the barograms, the times at which the successive waves passed the several stations can be estimated; and from these times the intervals between the successive passages of the waves from east to west and from west to east can be deduced. From the results obtained it followed that the wave travelled round the earth from east to west in 36 hours 57 min. and from west to east in 35 hours 17 min. From the velocities thus determined General Strachey has calculated from the known distance of each place from Krakatoa, the time occupied in the passage of the air-wave from Krakatoa to the place of observation, and the observed time of the passage of the waves. Combining all the observations, the rate of the waves moving from east to west gave for the time of the origin of the disturbance at Krakatoa 2·52h. Greenwich mean time, that is 9 hours 32 min. of the morning of the 27th August, local time. Treating the waves moving from west to east in a simi-

lar manner, the origin of the barometric disturbance was calculated to occur at 9 hours 13 min. local time. The mean of the two values obtained from the one series of waves travelling against the earth's motion or revolution and of the other of the waves travelling with it, fixes the time of the origin of the disturbance at 9 hours 24 min. local time 27th August. The velocity of the waves travelling from east to west was 674 miles per hour; of those passing from west to east it was 706 miles. No very exact comparison with the velocity of sound is possible, as this varies with the temperature: at 50° F. it is 757 miles per hour; at 80° it is 781 miles. The wave travelling from east to west was perceptible on the tracings for 122 hours after its origin: it travelled upwards of 82,000 miles, and had passed 3¼ times round the entire circuit of the earth before its extinction."

"It was, of course to be expected that the influence of this wave might be recognised at Leeds. Through the kindness of Mr. Branson, of the firm of Messrs. Reynolds and Branson, I have had the opportunity of inspecting the tracing made by one of their self-registering aneroids for the week comprised between August 27th and September 2nd. The curve, although on a smaller scale than those engraved on Mr. Scott's paper, is precisely similar in character to the barograms from Aberdeen, Stonyhurst, Glasgow, Armagh, and Valentia Island. The first rise at these places occurred on August 27th, at from 1 to 1.20 p.m.; the first fall varied from 1.25 to 1.48; the second rise at from 1.53 to 2.25 p.m.; the amplitude of the oscillation being about ·05in., and its duration about an hour. Owing to some slight imperfection in the action of the instrument, due probably to the fact that the new paper for the week was introduced shortly before this time, the tracing is not complete for the morning of Monday, the 27th. The next movement, however, is well marked. The rise occurred at about 3 a.m., and the depression at about 3.45, which is almost identical with the times of the other stations; the amplitude was about ·07 in. On the 27th there was another disturbance, shown on the Leeds tracing to have occurred at about 2 a.m.; the times at the other stations were 1.50 a.m. at Aberdeen, 2 a.m. at Stonyhurst, and 2.28 a.m. at Valentia. On the same day there was a disturbance due to the wave, travelling from west to

east. It was felt at Valentia between 1.27 and 2.10 p.m.; at Stonyhurst from 1.48 to 2.33 p.m., and at Aberdeen from 1.53 to 2.30 p.m. It very plainly indicated on the Leeds curve as occurring from between 2.0 or shortly before, and 2.30 p.m.; the amplitude of the oscillation was about ·03 to ·04 inch. The Aberdeen, Stonyhurst, Glasgow, Armagh, and Valentia curves further indicate a disturbance travelling from east to west between 2.45 and 3.45 p.m. It was well marked at Stonyhurst, the greatest depression occurring at about 3.15. The time and shape of the deflection are exactly reproduced on the Leeds tracing.

"Many years ago Humboldt showed that it was possible to tell the hour of the day at the equator, with a certain approach to accuracy, from the height of the barometer, owing to the comparatively wide range of its diurnal variation within the tropics. This fact, however, pales into insignificance when compared to that of determining the the time of a volcanic outburst, thousands of miles away, from the rhythmic succession of a few minute depressions in a barometric tracing."

1884.

THE EAST ANGLIAN EARTHQUAKE, APRIL 22ND, 1884.

"Soon after Nine on the morning of Tuesday, April 22nd, 1884, the eastern parts of this country were shaken by a seismic disturbance, which, although happily unattended by loss of life, for destructiveness and wide distribution has been without a parallel in Britain for at at least four centuries."

The report of this earthquake has been published as a separate volume by the Essex Field Club (pp. 223), being edited by Professor Meldola, F.I.C., F.R.A.S., &c. (Macmillan & Co.)

The report concludes by the following notice of the influence upon the recording barometer, at Leeds.

"While the foregoing report has been going through the press, we have learnt, through a communication to the "Leeds Mercury", that the shock recorded itself in that town on the tracing-paper of a recording barometer, although, as far as we have been able to ascertain, the movement itself was not perceived by anyone. The following is the communication in question:—

'Having examined the diagram traced by our recording barometer to-day (April 22nd, 1884), we find that between 9.15 and 9.30 a.m., the ink-line thickened suddenly, whilst a general movement downwards is shown. A thickened line continued to be produced until 1.30 p.m.. when the tracing regained its usual character. During this period of four hours six distinct undulations of the line are registered, the greatest of which measures ·025 in. Signed, Reynolds and Branson.'

As Leeds is about 171 miles from the focus, this observation is of the greatest interest; and on communicating with Messrs. Reynolds & Branson this firm was good enough to forward the tracing, with an explanatory letter in which they state that the instrument was not observed till late in the afternoon, as they did not hear of the Essex earthquake before that time. It appears that the air-wave produced by the Krakatoa eruption of 1883 was recorded by the Leeds barograph, as it was by similar instruments all round the globe, and this led to the examination of the tracing on the present occasion.

An inspection of the tracing forwarded by our correspondents fully bears out this statement, the "wobbling" of the pen (or tracing paper) having produced a series of six indentations in the line, of which the maximum, and last was traced about 1 p.m. This result is of great importance from a seismological point of view, and we may take the present opportunity of pointing out its significance.

As an earthquake-disturbance spreads outwards from its origin, the vibrations become longer in wave-length and period, and decrease in amplitude, so that the short and rapid movements which cause damage at the focus become slow, wave-like pulsations of the ground at great distances from the focus. The slow oscillations thus produced at a distance from all great earthquake centres may be aptly compared to the "after-swell" observed upon a coast after a distant storm at sea, the movements caused by distinct earthquakes, generally revealing themselves only by the oscillation of the water in ponds, lakes, etc. The effects of the great Lisbon earthquake of 1755 upon the inland waters of this country were doubtless due to such a slow surging of the solid ground. That the undulations in

the Leeds tracing were not due to atmospheric disturbances appears almost certain, both from the character of the indentations as well as from the fact that no other barograph has recorded them. On the other hand it is not at all improbable, that the Leeds instrument may, by its construction, be particularly sensitive to earth-shakes. It is of interest to consider in connection with the present report, that the disturbance originating beneath our county, was sufficiently intense to cause the ground 170 miles away to be tilted slowly to and fro for a period of four hours after the event."

NOTE.—Although the following notice cannot be classified amongst barometrical disturbances due to abnormal causes, it is so exceptional in character that it appears to be desirable to place it upon record.

On Wednesday, Dec. 8th, 1886, a terrible storm swept over England, unhappily attended by the loss of more than twenty men of the crews of two life-boats on the Lancashire coast. On Dec. 7th, at 8 p.m., the recording aneroid barometer stood, in Leeds, at 29·43 in., and a depression commenced which at 4 a.m., on December 8th, made the reading 29·20; at 10 a.m. it was 28·35, the fall having been very rapid and nearly uniform in speed for ten hours, during which 1 inch was lost. The fall continued until 9-30 p.m., when 27·68 was registered, being the lowest point reached. The readings of the aneroid were controlled at intervals by those of a standard mercurial barometer. As the charts are not ruled for lower readings than 28 in., Mr. Branson provided for the exceptional position by "gearing up" the instrument ½ in. The reading now reported appears to be lower than any previous one noticed in local records. The force of the wind in Leeds was not so great as to prove destructive.

ON THE HABITATION TERRACES OF THE EAST RIDING.

BY J. R. MORTIMER, ESQ., F.G.S.

These terraces must not be confounded with the cultivated terraces which are so common in the immediate vicinity of old villages, and are undoubtedly the work of the Roman and mediæval plough.

The lance-pointed terraces or platforms, which form the subject of this paper, are visible on many of the steep hill-sides of the Yorkshire Wold valleys, and many others which have once existed have now been erased by natural or artificial causes. They are quite distinct from any other form of earthworks or hill-side ledges, and where they remain perfect in outline, are remarkably alike both in shape and in size. They are generally found on that side of the valley which faces the morning or the mid-day sun, at about one-third the distance from the foot of the slope, and run parallel with the course of the valley. They are found in some cases as single platforms, in others as double platforms, whilst sometimes there are three or even more terraces running parallel one above another. One end of each terrace is always of full width, while the other end runs out to a fine point; and it is also worthy of note, that when two or more of these ledges are found lying like steps, one above the other, they always have their wide ends in the same direction. When well-preserved, they are found to have a breadth varying from fifteen to twenty-one feet, and a length of one hundred to two hundred yards. I know of no written allusion to this peculiar form of terrace, which is seldom found mapped even on the ordnance sheets. From 1863 to 1865 I took the measurements of several of the most perfect of these terraces; but could not, for a long time, determine their purpose. I hope that the following descriptions may enable other observers to recognize similar terraces in other parts of the country.

No. 1. This terrace was 135 yards in length, with an average width of about 6 yards, except at the pointed east end. It is found in Rain Dale, near Fimber, and is situated a little distance above the foot of the hill-side, facing N.W.

No. 2. This terrace is a little to the east of that described above, and though partially obliterated at the time of our research it seemed to have its broad end cut across by the old British entrenchments which encircle the village of Fimber.

Nos. 3 and 4. These are on the S.E. hill-side of Rain Dale, a few feet one above the other. They had been a long time under the plough, and were partly effaced. An excavation, which was made across them, showed an accumulation of soily matter, in some places 1½ to 2 fect in thickness, at the bottom of which lay pieces of animal bone, and several fragments of a kind of coarse pottery, much resembling the dark kind rarely found whole, but not unfrequently in fragments, in British barrows.

Nos. 5 and 6. These are also together, on the north side of the railway, between Fimber and Burdale. They are cut obliquely by an old filled-in hollow-way (fig. 1), one of six found radiating from the village of Fimber. The great age of these two terraces is shown by their being intersected by the hollow-way, as this contained fragments of Roman pottery in all the three sections which we dug across it, but in no case was the pottery found lower than half its depth, indicating that this road had been disused and half filled up by slowly accumulating debris, before the pot-sheds found their way into it. This is strong evidence that it was constructed in pre-Roman times, while the terraces are still older. Outside the area immediately surrounding Fimber are many similar terraces on the sides of the valleys, some being in fine preservation. One of these is well shown on the hill-side, close by the south side of the road from Raisthorpe to Thixendale. It is cut across by a chalk pit, and the section thus obtained clearly shows that the form of the terrace is due to material having been removed from its upper to its lower side, and there can be no doubt of its artificial construction. Two fine terraces, one above the other, curve round the N.E. end of Brubber Dale, about a mile-and-a-half to the north of Fridaythorpe. They are about ten yards above the valley bottom, and face the rising sun. Again there is a series of three terraces, pleasantly situated on the western hill-side of Wad Dale, about one mile N.N.W. of Weaverthorpe. At the time of my survey, Oct. 5th, 1883, the east end of Wad Dale plantation

covered the ground, and the terraces were sharply defined. In every case these terraces show most clearly that they have been made with a definite purpose. It has been suggested by Mr. Stackhouse that the somewhat similar terraces he observed on the hill-sides in the South of England, had been made by the ancient Britains as advantageous stations for placing their war-chariots before a battle, from which they might swoop down upon their enemies with greater force. But it seems to me that for such a purpose their form and position is quite unsuited, indeed almost impracticable; and I think that these simple hill-side terraces could hardly have been made for any other purpose than as sites of primitive dwellings. Their narrow ledge-like form and situation, on ground generally with a cheerful aspect and difficult to approach, would make them a pleasant and somewhat secure position for habitations such as would be erected by a few early hunters. At that time this neighbourhood would be more or less a wooded district, and, it is fair to presume, sufficiently well stocked with game to supply a scanty population whose wants were few, with food and and clothing, and the large game which would mostly move along the bottom of the valley could be readily observed by the occupiers of these ledges.

Since writing this paper, Mr. Foote, of the Indian Geological Survey, has discovered similar pre-historic artificial terraces in India.* The abstract of Mr. Foote's paper states that "in December, 1885, he re-visited Bellany, and looked up the localities where he had found the celts, both chipped and polished. Mr. Foote's reasons for regarding many of the localities at which he got numerous celts and other implements, as old settlements or village sites of the celt makers, are the following: Whenever the celts and other implements were found in large numbers, the hills on which they were found showed many signs of human habitation. Many small terraces have been raised among the great blocks of granitic gneiss of which all the hills but one consisted. Many of the terraces were evidently constructed with reference to the convenient proximity of rock shelters, and in most

* Journal Anthropological Institute, vol. xvi., No. 1, p. 72.

cases they lie on the eastern flanks of the hills, where they obtain shelter from the blazing afternoon sun." And he adds: "On the terraces and flats are large quantities of flakes produced by the manufacture of the implements, and implements in all states of completion."

These artificial terraces are most probably imitations of natural ledges, such as are on the hill-sides in other parts. In the early ages man would select these natural platforms as secure and suitable places for his dwellings, and where nature had not placed them he would with his own hands supply their absence. They denote a very early state of culture, and probably were the first earthworks constructed by man in this neighbourhood.

That man did occupy natural hill-side terraces in early times we have substantial evidence. During the summer of 1885, Mr. W. Horne, of Leyburn, discovered on a natural terrace on the limestone escarpment called "Leyburn Shawl," ancient interments, one of which was accompanied by a unique article of bone, which had probably served to secure a skin garment, He also found bones of the reindeer and the red-deer, chipped flints, fragments of rude pottery, and numerous collected sandstone boulders, reddened and cracked by fire, which he believes to be pot-boilers. There is also a carefully constructed cairn on this terrace, which Mr. Horne has already partially opened, aud intends completing it. Here we have evidence that in early times there was often but a step between the habitation of the living and the house of the dead.

NOTES ON THE PALÆONTOLOGY OF THE WENLOCK SHALES OF SHROPSHIRE. (MR. MAW'S WASHINGS, 1880.) BY GEORGE ROBERT VINE.

In his presidential address to the Geological Society, Feb., 1881, Mr. Robert Etheridge gave a full synopsis of the then known British Wenlock fauna. The number of genera and species that had been tabulated up to that time were, for 13 groups of fossils, 171 genera and 536 species. He also stated that 58 genera and 125 species

were "common to the Wenlock rocks aud the Upper Llandovery: or in other words these 125 species pass up from the Llandovery to the Wenlock formation."* The geographical distribution of these species include North and South Wales, Westmoreland, Scotland, and Ireland. By far the greater number enumerated are found in the Wenlock limestone series, the debris of which has been so persistently searched for fossils, both by the palæontological student and by the general dealer in fossil organisms, and the results of their united investigations are by no means surprising. In the Catalogue of Fossils in the School of Mines (1878) the whole of the Cambrian and Silurian fauna are carefully tabulated, stratagraphically, and while the Wenlock limestone fauna occupies twenty-three pages of the catalogue, the fauna of the Wenlock shales, to which attention will be presently directed, are catalogued on ten pages only. In the same presidential address Mr. Etheridge furnished a series of tables of the distribution of species in the different Palæozoic horizons, which to the student of Stratagraphical Palæontology is most valuable.

The whole of the then known Wenlock shale fauna were included in twelve classes, and are as follows:—

Class	Hydrozoa	5	genera,	probably	7	species.
"	Actinozoa	3	"	"	3	"
"	Echinodermata	6	"	"	7	"
"	Annelida	5	"	"	5	"
"	Crustacea	18	"	"	41	"
"	Polyzoa	2	"	only	2	"
"	Brachiopoda	15	"	about	42	"
"	Llamellibranchiata	23	"	"	27	"
"	Gasteropoda	5	"	"	6	"
"	Pteropoda	4	"	"	4	"
"	Heteropoda	1	"	"	1	"
"	Cephalopoda	5	"	"	18	"
		92	"		163	"

If then we deduct the 92 genera and 163 species from the list of Wenlock limestone forms given above by Mr. Etheredge, it will be seen that there are 79 genera and 373 species less in the shales than in the limestone. Since the catalogue was compiled, and even since

* Pres. Address, Quart. Journ. Geol. Soc., Feb., 1881, p. 132.

Mr. Etheredge delivered his address, much of the old material has been re-worked, and many new species have been added to previous lists, but only a few classes have been persistently overalled by the palæontological student, notably the brachiopoda by the late Dr. Davidson, and the polyzoa, annelida, and entomostraca, by myself, Prof. T. Rupert Jones and Dr. Holl; if then we are to compare favourably the list of Wenlock shale fossils, now given at the end of this paper, we must except the genera and classes which have neither been added to nor reduced in number. The excepted genera, and their included species belong to the classes hydrozoa, lamellibranchiata, heteropoda, and cephalopoda, and this will reduce the genera dealt with to 58, and the species to 110. Taking the Upper Silurian fauna generally, as given by Mr. Etheredge, we find that though there may be an absolute unconformity of the Upper Llandovey beds to the strata below "the changes of species in the two horizons may be due to causes of which we have no positive proof," yet, as Mr. Etheridge suggests, "looking at the intimate connexion between the fauna of the Lower Llandovery and that of the Upper, we are led to suppose that it was not of sufficiently long duration to cause either the extinction or migration of the older fauna or the introduction of a new one (only 4 genera seem to have appeared): for . . the Lower Llandovery transmitted 45 genera and 104 species out of its fauna of 68 genera and 204 species to the Upper Llandovery. It is therefore evident that upheaval and denudation must have been of comparative short duration, and little physical change could have taken place in the area occupied by the Lower Llandovery after upheaval: this the physical geography and palæontology of the two groups help to show."* Of the transmitted groups of fossils from the one horizon to the other, many of the species are as common to our own rocks as to the Upper Silurian rocks of Gotland,† yet I find that many genera and species common to the Gotland groups are very poorly represented in our own Wenlock shales. The causes of this may be manifold, but one chief reason for the paucity may be ac-

* Op. cit. p. 125.

† Dr. Lindstrom's list of Fossils, 1885, is before me while I write.

counted for in a very simple way—the want of persistent research and careful tabulation of the fragmentary remains as well as unbroken specimens.

It would have been impossible, at the time Mr. Etheridge was compiling material for his address, to have furnished a list like the present one. Why we are able to do so now may be briefly restated—though fuller details will be found on reference to the pages of the Geol. Mag. for 1881.

Messrs. George Maw and Mr. T. Davidson in the March number of that periodical, p. 100, gave a very full account of the washing of Wenlock shales for the purpose of illustrating results, but of one group only, viz., the Brachiopoda. Mr. Davidson says that between fifty and sixty thousand specimens were brought to light by the means employed, but even that does not fully represent the wealth of even the Brachiopadal remains in the shales, if I may be allowed to judge, from my own experience in the matter. Many interesting details are given by the authors, and we gather from these that altogether about 20 tons of the shales, from different localities, were washed and hand picked for Brachiopoda alone. Taking then a few horizons, which will be again referred to further on, we find that from one cart load of the shale from the Buildwas beds 4,300 specimens of Orthis biloba were obtained, "besides a much greater bulk of other Brachiopoda, amounting altogether to 10,000 specimens at least: but this does not nearly represent the full wealth of life of this rich horizon, as many of the larger species, and others not completely calcified, would get broken up in the washing process." This is true in every sense, and my connection with the shale washings is wholly due to the suggestive sentence which follows immediately after the close of the paragraph quoted (op. cit. p. 101.) "The whole of the debris has been preserved," say the authors, after "picking out the Brachiopoda, as it abounds in minute corals and other fossils, which will, we hope, be investigated by other observers."

Immediately after reading this paragraph I wrote to Dr. Davidson for some of this reserved debris, and in a very kind letter which he wrote he referred me to Mr. G. Maw, in whose keeping it was. Not many weeks elapsed, however, after my request was so ably

backed, before I received ample supplies from Mr. Maw. The debris itself, washings probably from about sixteen tons of shale, weighed nearly two-and-a-half hundred weight, packed in eleven small boxes, each box representing, if not a different horizon of the shales, at least a different locality. Since May, 1881, I have given most of my leasure time to the picking out of the minute as well as the larger organisms from this mass of material, always with a hand-glass under my eye, which magnifies from five to twelve-and-a-half diameters. In this way more than two-thirds of the material supplied to me have been carefully searched. Of the Actinozoa, Echinodermata, Crustacea, including the Entomostraca, Annelida, Polyzoa, Brachiopoda, and Gasteropoda, I have, without exageration, at least 200,000 specimens. The Polyzoa (partially) I give a description of in the present number of the proceedings, and in past years, in the pages of the Quarterly Journal of the Geological Society, I have described Polyzon and Annelida. In the Annals and Mag. of Nat. History, for 1886,* Prof. T. Rupert Jones, F.R.S., and Dr. Holl, have described several groups of the Entomostraca, other descriptions to follow, all pickings from the Wenlock shales. It gives me great pleasure to speak of the kindly co-operation of these specialists, and had I met with some one who would have co-operated with me, the Actinozoa division, chiefly the Monticuliporidæ of my list would have been much fuller than it is. The Monticulipora and Actinozoa tabulated are chiefly those which have been fully described by Dr. Nicholson in his published writings, and details may be found in "The Tabulate Corals,"† and in the "Genus Monticulipora."‡ Other species are given from the same author's papers on Palæozoic Micro-palæontology, in the Annals and Mag. of Nat. History. Otherwise I have not cared to load my list with MS. names. In some cases, however, I have been able to indicate affinities, and these I have not kept in the back-ground. Of the Brachiopoda of the list, I have depended largely upon the published writings of Dr. Davidson, but even in that group I have given the results of my own investigation, rather than mere extracts from the papers, and my species were named for me by Dr. Davidson himself. While searching the shales the Dr. always took a kindly interest in my special labours, whenever I sought information from him res-

* April and May numbers. † Edinburgh, 1879. ‡ Ibid, 1881.

pecting fossils belonging to his speciality. Mr. John Young's labours may also be referred to in connection with the shales, as we owe to him remarks on the shell structure of Eichwaldia Capewelli, Dav., Geol. Mag., 1885, and while he was searching independent virgin shale from the Buildwas and Tickwood beds, also supplied by Mr. Maw, he communicated to me the results which I have embodied in the No. 25x of Prof. T. Rupert Jones' Entomostraca papers. Dr. Davidson, however, in his list of Brachiopoda, Geol. Mag., 1881, pp. 108-109, does not specialise his various localities, but below the Wenlock limestone and above the Upper Llandovery beds he furnishes us with four very safe divisions:—

4. Upper Wenlock Shales (Tickwood Beds, -	No. 8. Dav.)
3. Middle Wenlock Shales (Coalbrookdale Beds,	,, 9, ,,)
2. Lower Wenlock Shales (Buildwas Beds,	,, 10, ,,)
1. Basement Beds of W. S. (or Buildwas Park Beds	,, 11, ,,)

and the reasons given by Dr. Davidson for these divisions, are, speaking generally, correct, based as they are upon Palæontological evidence. But in supplying me with the material Mr. Maw gave five numbers for the Buildwas beds which he wished me to keep intact. These I have preserved, and though I will not attempt to alter the decision of Mr. Davidson, it may be well to give to the palæontologist the benefit of Mr. Maw's notes on the localities, especially so, as I find very different organisms in the material bearing the different numbers now to be referred to:—

No. 4. Upper Wenlock shale represented in the following lists by number 41, 42, 25

,, 3. Middle Wenlock shale represented in the following lists by number 43.

,, 2. Lower Wenlock shale represented in the following lists by numbers 22, 37, 36, 38, 40.

and unless No. 22 will correspond with the basement beds of Mr. Davidson, I have no other number that will fit in.

Over the Wenlock limestone, which is No. 7 of Mr. Davidson, there is another lot of shales and this completes the Wenlock series of the authors:—

No. 6. Shales over Wenlock limestone, and these beds are represented by Nos. 24 and 46.

Speaking now generally of the shales which lie below the Wenlock limestone it is estimated that they attain a thickness of from 2000 to 2200 feet below the Shropshire escarpment. Immediately below the Wenlock limestone there are a series of beds which are conveniently called "the Tickwood Beds," and these are roughly supposed to include a thickness of from 300 to 500 feet of strata. My Tickwood material is derived from three localities.

No. 41 are washings from the shale under Wenlock limestone, at the foot of Benthal Edge and opposite Tickwood.

,, 42 is from the road-side at Tickwood, between Buildwas and Wenlock.

,, 25 is also from strata similarly described.

It is very certain that these shales are differently derived although they are apparently belonging to one horizon.. In the No. 25 washing, both coarse and fine, the organisms are far more perfect than in the washings from Nos. 41 and 42. Entomostraca are very abundant both in species and in individuals; the corals are more minute, and the Polyzoa and Annelida, though occasionally fragmentary, are better preserved than in any of the other beds. In the Nos. 41 and 42 washings the fossils are larger and more tossed about, not altogether water-worn, than in No. 25, but the No. 42 washing is the best for the larger corals and also for the larger fragments of Trilobita.

My own finer clay, from which I have picked out my best Entomostraca, was obtained by the re-washing of material derived from the No. 25 bed; but as Mr. John Young, of Glasgow, requested Mr. Maw to send him some of the virgin material for washing and picking, I have no doubt that his No. 25x may have been obtained from a similar locality or horizon.* I have not incorporated Mr. Smith's researches with my own, but have given to his pickings an independent page, especially so as all his organisms, excepting the Entomos-

* The following is Mr. Maw's description to Mr. Young, April 28th, 1881, "Tickwood beds, Wenlock series. Shale from east end of Benthal Edge, opposite Iron Bridge, Shropshire."

traca and Protozoa, have passed through my hands, and have been named and compared with my own.

"The Tickwood beds contain all the five species of Spirifer found in the Upper Silurians of Shropshire, with a larger proportion of individuals than in any other zone. The Tickwood beds are also the highest horizon in which the new genus Glassia occurs, and Orthis biloba here attains its highest limit, with the exception that a few individuals occur rarely in the Wenlock limestone and Lower Ludlow.*

Below the Tickwood there is another series of beds which are sub-divided by Messrs. Davidson and Maw as follows:—

		Thickness.
Barren shales of Coalbrook Dale—		
	"Coalbrook Dale beds"	1100—1200 feet.
Fossiliferous zone of Buildwas—		
	"Buildwas beds"	80— 100 feet.
Barren shales of Buildwas Park—		
	"Basement beds"	500— 600 feet.

"These soft shales have largely determined the configuration of the contours of the district, and represent the sweeping Ape Dale valley of denudation, which spreads out for twenty miles below the supporting ridge of Wenlock limestone of Wenlock Edge, and have in Coalbrook Dale yielded to the excavation of the picturesque valley." †

No. 43 washing is from these middle shales, or Coalbrook Dale beds, and is derived from Marmwood, which is situated between Coalbrook Dale and Buildwas.

Here the material is more water-worn than in any of the beds examined, at the same time much of the fauna is very characteristic, as will be noticed by a reference to the list. With regard to abundance of individuals this washing will vie with any of the other beds, but it appears to me that though the Coalbrook Dale beds may have a fauna of their own, still the persistent character of the fossils indicate a beach-like accumulation of deeper-sea forms.

The Buildwas beds, certainly the most abounding in organic

* Davidson, Geol. Mag., 1881, p. 103. † Ibid, p. 104.

remains of the whole series, are situated nearly at the base of the Coalbrook Dale clays, and so far as certain life forms are concerned, are entirely cut off palæontologically, from the overlying rocks. Messrs. Davidson and Maw say, "Below the fossiliferous Tickwood beds, from 1800 to 1900 feet of soft shales occur, which are comparatively barren in organic remains, excepting only that at one-third from their base a remarkably rich zone occurs, the horizon of which seems to correspond closely with the Woolhope limestone of Herefordshire, and possibly of the Barr limestone of Staffordshire, though in Shropshire the calcareous element is wanting. It is exposed on the east bank of the river Severn, a short distance above Buildwas Bridge, in a section including from 70 to 80 feet of shale beds. They are also exposed further to the west, by the side of the brook, south of Harley."*

The material from these beds, supplied to me by Mr. Maw, is more abundant, and comparatively speaking, much more important than from any of the other shales. The organic remains are innumerable, and it was only when I began to pick out specific fragments for mounting that it was possible for me to speak satisfactorily of the life history of the various groups. The Crinoid stems are abundant in the No. 38 washing, and are largely encrusted with foreign objects. In July, 1881, soon after receiving the shales, I made a calculation of the number of organisms on 1000 Crinoid stems, picked out at random, 86 were encrusted by Monticuliporæ, 80 by Stomatoporæ and Ascodictyæ, 7 by Ortonia, 27 with disk-like beginnings of various Monticulipora sp., 24 root-like process or beginnings of young Crinoids, 228 pustulose specimens (borings by sponge?), and about 550 fragments were comparatively free from encrustations or borings.

The organisms from the No. 36 washing are in some respects of a very specialised character, but my reasons for placing the collection after the Nos. 22 and 37 may be inferred from this. The Nos. 22 and 37 washings, though poor in many other organisms, are literally crowded with fragments of Trilobita, and the Entomostraca are also of a very special character; Actinozoa are especially rare; restricted species of Polyzoa fairly abundant.

* Op. Cit., p. 103.

Nos. 38 and 40. These washings, Mr. Maw says, are the same, and the shales were obtained from exposures near the base of the Wenlock shale, on the banks of the river Severn, above Buildwas Bridge.

No. 36 is also from the base of the Wenlock shale, but from the middle of the exposure.

No. 37. "Washing from Buildwas beds, near the base of Wenlock shale, north end of exposure, side of river Severn, above Buildwas Bridge, Shropshire." G. Maw.

No. 22. Washing from the base of the fossiliferous zone of Buildwas beds, Harley, near Wenlock.

Above these various zones at Benthal Edge, the Wenlock limestone, No. 7, of Mr. Davidson's divisions, "dips from 15° to 20° S.S.W.; to the westward the dip decreases from 10° to 15°, and at the eastern extremity of the escarpment of Lincoln Hill, near Coalbrook Dale, the inclination increases to from 45° to 50° . . . . . From careful measurements made on Benthal Edge it has been ascertained that the compact limestone is from 80 to 90 feet in thickness, and it thickens somewhat in the direction of Wenlock to the south-west." *

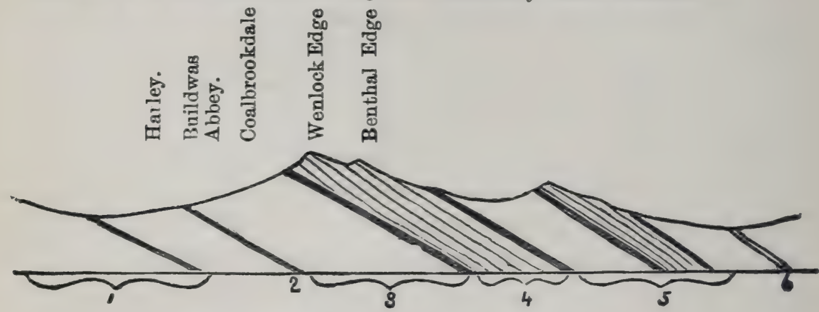
Overlying the Wenlock limestone there are some soft shales, about 100 feet in thickness, and these are exposed in cuttings by the side of the railway between Buildwas and Wenlock. The material represented by No. 24 was contained in a very small package, and it is by no means remarkably characteristic.

No. 46 are washings from shales over the Wenlock limestone, and were obtained from the railway cutting between Wenlock and Buildwas. It is singularly rich in small corals, Entomostraca and the fry of Brachiopoda, many of which are similar to species found in the Wenlock limestone.

In my list of species I have endeavoured to represent, fairly as well as comparatively, the fauna of the different washings, and it will be possible for the palæontological student, with the list before him, to make comparisons of the fauna of the Shropshire shales, with the fauna of other Wenlock horizons, British as well as foreign.

* Op. Cit., p. 102.

"The Wenlock shales, in Shropshire, which cannot be much less than 1800 to 1900 feet in thickness, have a developement much in excess of the Wenlock shale in the Malvern district, where Professor Phillips estimated it to be 640 feet thick: indeed its thickness in Shropshire is greater than in any other district, unless we except the supposed equivalents, the Denbighshire flags, which Mr. G. Maw believes will be found to belong to a distinctly lower horizon." *



1. Upper Llandovery.
2. Buildwas beds, Nos. 22, 37, 36, 38, 40.
3. Coalbrookdale beds, No. 43.
4. Tickwood beds, Nos. 25. 41, 42.
5. Wenlock limestone and shales, Nos. 24-46.
6. Ludlow series.

As there are a variety of opinions extant as to the proper placement of certain species of the Palæozoic Actinozoa, whether with the Cœlenterata or with the Bryozoa of American authors, the student will find ample details respecting these in a paper on the Silurian Polyozoa in the present part of the transactions. As, however, there are other species of which no details are furnished, the following brief notes may be acceptable.

1. Favosites Bowerbankia, Ed. & H. (Nicholson's Tab. Corals, p. 73.)

= Monticulipora ? Bowerbankia, Brit. Foss. Cor., p. 268.

There are two or three fragments which may be, though doubtfully, placed here. I cannot detect "mural pores" in them, but Nicholson says that "mural pores" are fewer in number in British than in Swedish examples.

* Op. Cit., p. 102.

2. Favosites Forbesii, Edw. & Haime. (Tabulate Cor., Nich., p. 258.)

= Favosites Forbesii, Ed. & H., Brit. Foss. Cor., p. 258.

Examples of this well-marked species are present in several horizons of the shales, but as small spheroidal or globular coralla, the longest of which is rather more than a quarter and less than half an inch in depth and breadth.

3. Pachypora frondosa? Nicholson, Tab. Cor., pp. 94-95, fig. 17.

There are a few fragments in my collection belonging to a small group, the type of which may be taken as P. (Alveolites) frondosa, Nich., while others are closely related to, as yet, undescribed species found in the Cincinnati rocks of America.

4. Pachypora cristata = Favosites polymorpha, Lonsd., Sil. Sys., p. 684, Ed. 1839.

Favosites cristata, Ed. & H., Brit. Foss. Cor., p. 260.

Examples of these species are found in the shale washings, but it is impossible to depend on external features, as a means of identification. Sections must be made of suspicious bits, and then, if there be a careful comparison both of the descriptive text and figures, all the details brought to light by Professor Nicholson (Tab. Cor., p. 87, pls. iv. and v.) will be observed. The corallites radiate from the axis of the corallum, diverging outwardly to open on all sides of the free surface, their walls are thickened by "schlerenchyma," especially towards the mouth. The calices are sometimes rounded, with greatly thickened margins, and are usually of two sizes: generally speaking, from two to two-and-a-half occupy the space of a line.

5. Syringopora fascicularis, Ed. & H., Brit. Foss. Cor., p. 274.

I have only rarely obtained examples in "fasciculæ," as described by Edw. & Haime. Fragments of single corallites are abundant, and I am not surprised to find that some of these are referred to by authors as Aulopora sp., Goldfuss.

6. Syringopora serpens, Ed. & H., Brit. Foss. Cor., p. 275, pl. lxv., fig. 2-2a.

=? Aulopora conglomerata, Lonsd. Sil. Sys., p. 675.

Found generally in fragments, and some separated corallites closely resemble Aulopora.

Family AULOPORIDÆ Nich., Tab. Cor., p. 219.

I have in my collection a number of fragments that may ultimately find a resting place in this family. They seem to me not to belong to species of Syringopora, Goldfuss. Some examples resemble Cladoconus M'Coy, and appear to be related to C. Michelini Ed. & H., and others to the singular genus Monilopora Nich. & Eth., Jun. But as species of this genus are Carboniferous, I cannot place them here with confidence.

In his paper on the Corals and Bryozoans of the Lower Helderberg group.* Mr. James Hall describes several examples of Aulopora, and judging from the written descriptions, some of our own species may be closely related to the Helderberg group. In the absence of figures or fossils I cannot say.

9. HALYSITES CATENULARIA, Linne. = Catenipora, Lonsdale.

Fragments belonging to this and to some other of the synonymous forms given by Ed. & H., Brit. Foss., pp. 270-1, are very abundant in the washings, but generally water-worn.

10. HALYSITES ESCHAROIDES, Linne. Catenipora id., Sil. Sys., p. 685.

If I relied solely upon the external characters it would be difficult to separate the two species which Edw. & Haime regard as one. But the fragments, though small, are valuable for sections, and "by means of microscopic sections . . . the form known as H. escharoides Linne, is distinguished from the typical H. catenularia Linne, not only by the superficial characters, but also by the constant possession of spiniform septa, and the apparently constant absence (?) of small tubes between the larger ones.†

11. THECIA SWINDERNANA, Edw. & H., Brit. Foss. Cor., p. 278.

Fragments of this species are abundant in the shales, but it is only rarely that specimens can be obtained that will show the beautiful superficial characters.

12. HELIOLITES INTERSTINCTA, Linne. See Brit. Foss. Cor., p. 249.

This well-known species, which had a wide range in Silurian times, is found in the shales in fragments or what really appears to be full-sized

* Albany, 1880, 32nd Annual Rept. of the State Mag., N. York.

† Nicholson's Tab. Cor., p. 229. ? mine.

colonies, only that they are small. Adherent to a fragment of Halysites is a young colony of Heliolites. The primary corallite is rather long and pointed at the proximal extremity. At about half-a-line from the point is the first calicular cup. It appears that the first corallite is produced by gemmation (?) from the primary, then the secondary produces another corallite latterly, which is the cause of the first increase in the width of the colony. Many of the free fragments in the shales clearly show that the first stage in the growth of the colony was parasitic on some other fossil.

13. HELIOLITES MEGASTOMA, M'Coy. Edw. & H., Brit. Foss. Cor., p. 251.

Fragments of this coral are present in the washings, and the two species are easily distinguished when compared together, the calices being more closely set in one than in the other species.

14. CALLOPORA NANA, Nicholson. Ann. Mag. Nat. Hist., 1884, p. 120, pl. vii., figs. 4-4b.

This beautiful species was originally described by me in a paper sent on for reading to Professor Duncan, Dec., 1882, but not published, as Monticulipora fistulosa, but as my original description contains a few particulars not noticed by Professor Nicholson, I make no scruple in adding to his description, especially as my own diagnosis was drawn up from hundreds of specimens from the Buildwas beds.

Corallum, in its earliest stages encrusting, after which it assumes a globose, oblong, or an irregularly branching shape. Corallites large and small in its earliest or encrusting stage, the small corallites cover as a delicate film some foreign body; if the object should be circular, then future developement of the colony will be either a small pill-like globe, or a delicate stem, and the shape of the future colony is to a large extent dependent upon the shape of the object which it originally encrusts. In this early stage also all the smaller corallites are either oval or oblong, with circular corallites interspersed here and there. After about the space of a line, more or less, clusters of larger corallites make their appearance, surrounded by smaller ones; then again maculæ of the smaller groups intervene between normal corallites, which may always be distinguished by their circular character. Calices, occasionally covered with an opercula, which may

be described as a stellar plate, with a circular opening in the middle. Tabulae in both the larger and smaller corallites, less fully developed in the former.

Localities: Buildwas beds; No. 37 rare, Nos. 36, 38 and 40 very abundant. Water-worn and identified only by sections—Coalbrookdale and Tickwood beds; rare also and water-worn in shales over Wenlock limestone.

15. CALLOPORA FLETCHERI, Edw. & H. (Nich. Op. Cit., p. 122, pl. vii., 5-56.

Professor Nicholson is quite right in separating these species, for though not so abundant in the Buildwas shales as the above, it is fairly plentiful. At the same time, I cannot help remarking that the difficulty of identifying the Buildwas examples with those from the Wenlock limestone is very great.

With regard to the contents of the list now presented to the Palæontologist, it must not be presumed that it gives an account of the whole of the Wenlock shale fauna, for that would be by no means a correct supposition. It is a list of the species found in the shales supplied to me by Mr. Maw; and though it may not be possible for me to add many more to the number of species, it is quite possible that local students may be able to add to it considerably; if such should be the case, I shall be glad to hear about the additions.

Since this paper was written, Mr. Thomas Ruddy's list of Bala fossils has come to hand.* This compilation is the result of ten years' labour in collecting, and as the range of certain fossils during the Palæozoic epoch was very wide, I have placed an asterisk (*) against the figures in the left-hand col., provided the species indicated range from the Bala to the Wenlock seas: otherwise I have not cared to load my list with references.

*** Proceed. Chester Soc. of Natural Sc.. pp. iii.. 1884, published, 1886.**

		22	37	36	38	40	43	41	42	25	W.L.	24	46
	PLANTÆ.												
1	Macrospores?												×
2	Spore-like markings on crinoid stems and shells	×	×										
	SPONGIDÆ.												
3	Borings in crinoid stems		×	×	×	×			×	×			
	HYDROZOA.												
4	Genus doubtful		×	×									
	ACTINOZOA.												
5*	Favosites gothlandica, Lam.										×		
6	Forbesi, Ed. & H.			×			×	?	×				
7	Bowerbankei, E. & H.								×	?			
8	Pachypora cristata, Ed. & H.						×	×	×	r.			
9	sp.						×						
10	Syringopora fascicularis, Ed. & H.						×	×	×	×			
11	serpens, Ed. & H.						×	×	×	×			
12	sp.			?						×			
13	Cladoconus ? sp.			×	×	×	×	×	×	×			
14	Monilopora ? sp.						×	×	×	×			
15*	Halysites catenularia, Linn.						×	×	×	×			
16	„ escharoidea, Linn.						×		×				
17	Thecia swindernana, Ed. & H...						×	×	×				
18*	Heliolites interstincta, Linn.						×	×	×	×	×		
19*	„ megastoma, M'Coy						×	×	×	×	×		
	Not fully worked:—												
	Cyathophyllum												
20	sp.				×								
21	angustum. Lonsd.	×					×		×				
22	sp.		×						×				
23	sp.			×									
24	sp.		×										
	Monticulipora, Nicholson.												
	Fistulopora, M'Coy*												
25	„ crassa, Lonsd.						×	×	×	×			
26	„ nummulina, N. & F.			?					?		N.		
27	„ dobunica, N. & F.			×		×		×			N.		
28	„ cornavica, N. & F.			×	×				?				
29	„ ludensis, Nich.†										N.		
	Callopora, Hall												
30	„ nana, Nich.	r.	r.	×	×	×	×	×	×	?	N.		×
31	„ Fletcheri, Ed. & H...			×	×						N.		
32	Decayia aspera, Ed. & H.		×		×	×							
33	Monticulipora sp. ... ... (not fully worked.)			×	×	×				×			
	Monotrypa, Nich.												
34	„ crenulata, Nich.‡										N.		?
35	„ pulchella, Ed. & H.				×					×	×		×
36	„ sp.		×	×	×		×		×				
37	„ sp.		×		×		×		×				
38	„ sp.		×		×				×				

* Ann. Mag. Nat. Hist.. Dec., 1885. † Ibid, 1884. ‡ Op. Cit., pp. 124-127.

No.	Species	22	37	36	38	40	43	41	42	25	W.L.	24	46
	Species requiring further study.												
	Monticulipora, Nicholson.												
39	= Chœtetes ? cyolosus Quenst.*			×	×								
40	= ? clavatus Quenst.			×	×	×							
41	= ? nudus Quenst.			×		×							
42	= ? anguiformis Quenst.				×								
43	= ? affinis Quenst. ... ... (not Ceriopora affinis Goldf.)			×		×				×			×
	ECHINODERMATA (Crinoids).												
44	Pisocrinus pilula ? D. Kon.			×	×	×							
45	Pentagonal stems (Crinoids)	×	×	×	×	×			×				
46	Circular stems, small and large ossicles ..	×	×	×	×	×		×		×		×	×
47	Star-like stems			×	×					×			
48	Circular stems, regular ossicles	×	×	×	×	×	×	×	×	×			
49	sp.	×				×							
50	sp.		×	×	×								
51	Glyptocrinus, plates of (Cystoidea ?)	×	×	×	×	×							
52	Plates of :—(Caryocrinus ?)		×			×							
53	„ „ —(Pseudocrinus ?)		×		×	×							
54	Pectinated rhombs of sp.	×	×		×	×							
	Plates and parts not classified.												
55	sp.	×	×	×	×	×							
56	sp.	×	×			×				×			
57	sp.			×	×					×			
58	sp.				×	×			×				
	ANNELIDA TUBICOLA.†												
	Cornulites, Schlot										×		
59	scalariformis, Vine					×		×					
	Conchicolites, Nicholson.												
60	Nicholsoni, Vine	×	×	×					×	×			
61	rugosa, Vine	×			×	×	r.			r.			
	Ortonia, Nich.												
62	pseudopunctata. Vine	×			×								
63	serpulariformis, Vine						×			×			
	Spirorbis, Lamarck.												
64	minuta, Vine	×											
65	Lewisii, Sowerby		?								×		
66	arkonensis ? Nch. sp.?	×								×			
	Tentaculites, Schlotheim,												
67	ornatus, Sby....						r.			r.			×
68	tenuis, Sby.										×		?
69	attenuatus, Vine									×			×
70	Wenlockanus, Vine	×		×	×		×			×			×
71	multiannulatus, Vine	×		r.	r.	r.				×			×

*F. A. Quenstedt Die Rohren und Sternhorallen Leipzig, 1881.

†Mihi, Quart. Jour. Geol. Soc., 1882, pp. 377-392,

		22	37	36	38	40	43	41	42	25	W.L.	24	46
	Psamosiphon, Vine.												
72	elongatus, Vine						×			r.			
73	amplexus, Vine						r.	×	×	×			
	Crustacea (not fully worked, but fragments in nearly all the horizons).												
74	Phacops, fragments of...		×			×			×				
75	Acidaspis, „	×		×	×	×			×				
76	sp.												
77	sp.												
78	sp.												
79	sp.												
	Entomostraca* (Not as yet fully described)												
80	Macrocypric Vinci, Jones & Holl				×			×		×			
81	„ elegans, J. & H.				×					?			
82	Pontocypris Mawii, J. & H.				×				×	×			
83	„ „ var. gibbera, J. & H. ...	×		×	×		×		×	×			
84	„ Smithii, J. & H.	×		×	×		×		×	×			
	Bythocypris Brady.												
85	„ Hollii, J. & H.												
86	„ reniformis, J. & H.	×											
87	„ siliquoides, J. & H.		?										
88	„ testacella, J. & H.		?										
89	„ symetrica, J & H., var. only		?										
90	„ Phillipsiana, J. & H., var. only ...	×					×						
91	„ phaseolus, J. & H.												
	Thlipsura, Jones & Holl												
92	corpulenta, J. & H.						×			×		×	×
93	v. scripta, J. & H.	r.					×						
94	tuberosa, J. & H.									×			
95	Cythere carbuloides, J. & H.						×		×				
96	„ ? Vinei, J. & H.								×	×			
97	„ ? subquadrata, J. & H.								×	×			
98	Cytherellina ? bisulcata, J. & H.												
	Æchmina, Jones & Holl.												
99	cuspidata, J. & H.									×			
100	sp.									×			
101	sp.								×	×			r.
	Beyrichia, M'Coy												
102	Kloedeni, M'Coy												
103	var. granulata	×								×			
104	„ nuda, Jones									×			×
105	„ intermedia						×			×			×

* Prof. T. Rupert Jones, F.R.S., and Dr. Holl Ann. Mag. Nat. Hist., 1886 & 1887.

		22	37	36	38	40	43	41	42	25	W.L.	24	46
	Beyrichia M' Coy (continued)												
106	,, sub-spissa						×			×			
107	,, sub-torosa						×			×			
108	,, tuberculata, Salt.	×					×			×			×
109	,, clausa, J. & H.									×		×	×
110	concinna, J. & H.												?
111	Maccoyiana, Jones	r.					×			×		×	
	? Jonesii. Boll.										×		
112	admixta, J. & H.									?			
113	lacunata, J. & H.									×			
	Bollia, Jones & Holl.												
114	bicollina, J. & H.	×	×	×		×							
115	uniflexa, J. & H.		×										
116	var.	×	×										
117	var?		×										
118	Vinei, Jones & Holl		×										
119	,, var. mitis, J. & H.		×							?			
	Klœdenia, J. & H.												
120	intermedia, J. & H.		×										
	Strepula, J. & H.												
121	concentrica, J. & H.									?			
122	irregularis, J. & H.									×			
123	beyrichoidea, J. & H....									×			
	Placentula, J. & H.												
124	excavata, J. & H.		?							×			
	Primitia, J. & H.												
125	lenticularis, J. & H.									×			
126	Romeriana, J. & H.		?										×
127	fabulina, J. & H.		×										
128	variolata. J. & H.						×						
129	paucipunctata, J. & H.	?					×			×			
130	valida, J. & H.												×
131	var. breviata, J. & H.						×						×
132	var. angustata. J. & H.												×
133	tersa, J. & H....								?				
134	umbilicata, J. & H.									×			
135	cristata, J. & H.									×			
136	cornuta, J. & H.		×			×							
137	æqualis, J. & H.		?										
138	diversa, J. & H.		×										
139	var.		×										
140	seminulum, J. & H.										?		
141	furcata. J. & H.										?		
142	ornata, J. & H.									×			
143	humilis, J. & H.	×	×							×			
144	punctata, J. & H.		×										

		22	37	36	38	40	43	41	42	25	W.L.	24	46
	Polyzoa (=Bryozoa)												
	Ascodictyon, Nich & Eth.												
145	filiforme, Vine	×	×	×	×	×						r.	
146	radiciforme, Vine			×	×	r.							
?	stellatum, Nich. & Eth.			×	×								
147	var. silurianense, Vine					r.							
?	radians, Nicholson...												
148	var. A.			×	×								
149	var. B.				×								
	Rhopalonaria. Ulrich.												
150	botellus, Vine...	×	×	×	×	×							
151	ulrichi, Vine			×	×								
	Stomatopora, Bronn.												
152	dissimilis, Vine	×		×	×								
153	elongata, Vine	×		×		×							
154	compressa, Vine									×			
	Diastoporella, Vine.												
155	consimilis, Lonsd.			×									
	Entalophora (Spiropora).												
156	regularis, Vine	×	×	×	×	×				×	×		×
157	intermedia, Vine									×			
158	? escharaforma, Vine	×		×	×								
	Fenestella, Lonsdale, 1839.												
159	prisca ? Lonsdale									×			
160	rigidula, M'Coy										×		
161	reteporata, Shrubsole									?	×		
162	lineata, Shrub.									?	×		
163	intermedia, Shrub.										×		
164	Fragments indeterminable								×	×			
	Polypora ? M'Coy.												
165	problematica, Vine	×	×	×	×	×							
	Pinnatopora, Vine.												
	Sedgwickii, Shrub. (Bala beds)												
	? sp....								?	×			
	Thamniscus, King.												
166	crassus, Lonsd =Hornera....									×			
167	delicatula, Vine	×											
	Glauconome, Goldf.												
168	disticha, Goldf.									×			
169	var. A.									×			
170	var. B.									×			

No.	Species	22	37	36	38	40	43	41	42	25	W.L.	24	46
	Ptilodictya, Lonsd. 1839 (not M'Coy) ...												
171	Lonsdalei, Vine	×	×	×	×	×				r.			r.
172	lanceolata, Lonsd.												
											×		
	Stictoporella, Ulrich.												
173	interporosa, Vine								×				
	Doubtful forms.												
	Eschara ? (Ptilodictya ?).												
174	scalpellum, Lonsd.				×				×	×			
175	Ptilodictya sp. (Vine)									×			
	The following are referred to Bryozoa by Dr. Lindstrom. (Catalogue of Foss. Gotland, 1885.)												
176	Discopora sp., Lonsdale			×	×	×							
177	" "												
178	Cladopora repens		r.	×	×								
179	" seriatoporides, Ed. & H.						×	×	×	×			
180	Cænites juniperinus, Eich.						×	×	×	×	×		×
181	linearis, Ed. & H.						×		×				
	Rhombopora ? Meek.												
182	Ceriopora granulosa, Goldf.	×	×								×		×
183	affinis, Goldf.		×								×		×
184	granulata Vine		×										
185	oculata, Goldf.		?								×		
	Brachiopoda.*												
186	Lingula Symondsii Salter			×		×							
187	Orbiculoidea Forbesii, Davidson					?							
	Pholodops (=Crania).												
188	implicata, Sby.				r.		×			×			
189	Discina sp.												?
190	Dinobolus Davidsoni Salt.										× D.		
191	Waldhemia Mawei, Dav.						×		×	×			×
192	? Glassei, Dav.			r.									
193	Meristella tumida, Dal.			×		×					×		×
194	didymia, Dal.												
195	læviuscula, Sby.	×					×			×			
196	? Mawei, Dav....										D.		
										×			
	Spirifera.												
197	plicatella			×									
198	radiata, Sby.			×			×			×			
199	var. interlineata						×						
200	crispa Linne	×		×			×			×			
201	elevata, Dal.			?			×	×					
202	sulcata His.						×						
203	Cyrtia exporrecta, Walk.						×						
204	Nucleosporia pisum, Sby.					×	×						

*See Geol. Mag., May, 1881-3, paper by Dr. Davidson, F.R.S.

		22	37	36	38	40	43	41	42	25	W.L.	24	46
205	Atrypa reticularis Linne		fg	fg		×	×		×	×			
206	aspera, Schlo.									×			
207	marginalis, Dal.									D	D		
208	imbricata, Sby.										D		
209	Barrandi, Dav.			r.			×		×	×			
210	Glassia obovata, Sby.		×		×		×						
211	elongata, Dav.								×	×			
212	Retzia Salteri, Dav.			×	×								
213	Bouchardi, Dav.			×		×				×			
214	Eichwaldia capewelli, Dav.	×	×	×	×	×				×			
215	Streptis Grayi, Dav.	×		×	×								
216	Pentamerus galeatus, Dal.								×				
217	lingulifera, Sby.						×						
218	Rhynchonella Wilsoni, Sby.												×
219	sphæroïdalis, M'Coy								×		D		
220	Lewisii, Dav.												
221	borealis, Schlo.									×			
222	bidentata, Sow.						×		×	×			
223	stricklandi Sby.								?				
224	cuneata, Dal.										D.		
225	nucula, Sby.										D		
226	Dayi. Dav.			?					×	×			
227	deflexa, Sby.									×			
228	sp.				×					×			
229	sp.								×				
230*	Orthis biloba* Linne	×	×	×	×	×	×	×	×	×	×		r.
231*	elegantula, Dal.	×	×	×	×	×							
232	elegantulina, Dav.	×		×									
233	hybrida, Sby.	×		×	×	×	×			×			
234	Bouchardi, Dav, ...								?		D.		
235	rustica, Sby.	r.		×							D.		
236	Lewisii. Dav.			×			×		×				
237	æquivalvis, Dav.			D.									
238	biforata Schol.			D.									
239	Streptorhynchus nasuta Lindst										D.		
240	Strophomena Dayi, Dav.					×		fg	fg		D.		
241	rhomboidalis, Wilk.						×						
242	furcillata M'Coy										D.		
243	imbrex, Pander												
244	pecten, Linn.				fg								
245	filosa, Sow.										D.		
246	Fletcheri, Dav.										D.		
247	Leptæna transversalis, Dal.						×						
248	segmentum, Angelin		×	×	×	×	×	×	×	r.			
249	Chonetes lepisma, Sby.												×
250	minima, Sby.	×		×									

* Only 1 specimen found in Bala beds, Rudder.

		22	37	36	38	40	43	41	42	25	W.L.	24	46
251	Lamellibranchiata (fragments)												
	Gasteropoda (not fully worked)												
252	Euomphalus sp....						×						
253	„ sp...						×						
254	Cyclonema sp.	×			×								
255	„ sp.						×						
256	Acrocula sp.		×	×									
257	„ sp.	×		×									
	Pteropoda.												
258	Conularia sp.				×								
259	„ sp.				×	×							

The following is Mr. Smith's Collection of Microzoa from the Wenlock Shales.

ANNELIDA PUBICOLA.	No. in my List.	Localities.
Cornulites scalariformis, V. ...	59	Lincoln Hill, Ironbridge
Conchicolites Nicholsoni, Vine ...	60	Railway cut., opposite Swan, Ironbridge
Ortonia pseudopunctata, V. ...	62	Lincoln Hill
Spirorbis Lewisii, Sby.	65	Lincoln Hill, Ironbridge
sp.	64	„ „
sp.	65 ?	„ „
Tentaculites Wenlockianus, V. ...	70	Railway cutting, Coalbrook Dale and Wenlock limestone
multrannulata, V.	71	Railway cutting, Coalbrook Dale
ornata, Sby.	67	„ „
Psamosiphon elongata, V. ...	72	Railway cut., opposite Swan, Ironbridge
amplexus, V.	73	„ „
POLYZOA.		
Ascodictyon filiforme, Vine ...	145	Railway cutting, Coalbrook Dale
„ „ „ ...	146	„ „ On Entomostraca, Malvern Tunnel, Red Shale
Stomatopora dissimilis, V. ...	152	Lincoln Hill, Ironbridge
Entalophora regularis, V. ...	156	Railway cutting, Swan
„ „ and variety		Railway cutting, Coalbrook Dale
„ intermedia ? Vine ...	157	„ „
„ escharaforma, Vine	158	Wrens' Nest, Dudley (very fine)
Fenestella fragments	159?	Lincoln Hill, Ironbridge
„ reteporata, Shrubsole	161	Wenlock Limestone
Thamniscus sp.		Gleedon Hills, near Muck Wenlock
(This sp. is different from T. crassa. Nine small punctures surround the orifice of cell.)		

Annelida Pubicola.	No. in my List.	Localities.
Glauconome disticha, Goldf. ...	168	Benthal Edge, Ironbridge
„ var. A.	169	Dudley Tunnel
Ceriopora granulosa, Goldf. ...	182	Woolhope (very beautiful specimen)
„ oculata, Goldf. ...	185	Benthal Edge
Ptilodictya Lonsdalei, Vine ...	171	Railway cutting, Coalbrook Dale
„ sp.		Benthal Edge, Ironbridge
Eschara ? (Ptilodictya ?) scalpellum, Lonsd.	174	Wenlock Limestone
Protozoa (Foraminifera)		
(None of the following species are in my collection.)		
Lagena vulgaris, Williamson		
var. clavata D'Orb		Sedgeley, Benthal Edge, Ironbridge,
„ lævis Montagu	...	Woolhope, Dorrington Hill
„ sulcata, W. & Jones ...		
Sponge spicules		Wren's Nest, Benthal Edge, Dudley Tunnel, Gleedon Hill
Spicules of Hyolonema ...		Rotted Limestone, near the Craven Arms
Conodonts abundant		„ „ „ with Entomostraca
Entomostraca.		
Beyrichia tuberculata var gibbosa Reuter		Dudley Castle
Beyrichia Kloedeni, M'Coy		
„ var. intermedia, Jones ...	105	Railway cutting, Much Wenlock: Woolhope
„ „ subtorosa, Jones ...	107	Ironbridge: Walsal ? : Stoke Saye
„ „ nuda, Jones	104	Wren's nest, Dudley
„ „ torosa, Jones ..		Dudley Castle
„ „ tuberculata, Salter ...	108	Ironbridge: Woolhope: Gleedon Hill: Wren's nest' Dud.: Benthal Edge
„ concinna. J. & Holl ..	120?	Dorrington, near Stoke Edith
„ Maccoyiana, Jones ...	111	Much Wenlock: Coalbrookdale: Walsall: Lincoln Hill: Ironbridge
„ Jonesii, Boll (Dr. Holl's collection)		Wenlock Limestone, Eastnor Park
„ admixta, J. & H.	112	Woolhope
„ lacunata, J. & H. ..	113	Ironbridge: Woolhope
Bollia bicollina, J. & H.	114	Woolhope
„ Vinei, J. & H.	118	Woolhope
Strepula concentrica, J & H. ...	121	Lincoln Hill: Ironbridge: Woolhope
irregularis, J. & H.	122	„ „ „
beyrichioides, J. & H.	123	„ „ „
Placentula excavata, J. & H. ...	124	Woolhope: Lincoln Hill: Ironbridge
Primitia lenticularis, J. & H. ...	125	Dudley Castle: Ironbridge: Red Shale Malvern Tunnel: Sedgely
fabulina, J. & H.	127	Dudley Tunnel
variolata, J. & H.	128	Side of Severn, Ironbridge
humilis, J. & H.	143	Woolhope
valida, J. & H.	130	Woolhope: Lincoln Hill: Ironbridge
tersa, J. & H.	133	Side of Severn, Ironbridge

ANNELIDA PUBICOLA.	No. in my List.	Localities.
umbilicata, J. & H.	134	Side of Severn, Ironbridge, and Dudley Tunnel
ornata, J. & H.	142	Woolhope: Lincoln Hill Ironbridge
æqualis, J. & H.	137	Coalbrookdale, Ironbridge
seminulum, J. & H.	140	Ironbridge: Lincoln Hill. Ironbridge Woolhope: Wren's nest, Dudley Benthal Edge
furcata, J. & H....	141	Dudley Tunnel

There are still many species of Entomostraca in Mr. Smith's collection not as yet (Nov., 1886) described and figured by Messrs. Jones and Holl. These I have not given. In the Feb. No. of the Geol. Mag, 1881, pp. 70-75. Prof. T. Rupert Jones gave a provisional list of the species, and there is also a brief account of Mr. Smith's method of preparation, and a full description of the 16 localities with the prevailing organisms found in each of the shale washings, which he so persistently searched for microzoa To these notes I refer the palæontological student with pleasure, knowing full well that he must profit by the perusal.

COLLIERY EXPLOSIONS AND THE WEATHER OF 1885. ANON.

Following a year of unexampled immunity from any serious loss of life, the year 1885 adds another to the list of excessive totals of deaths. The number of explosions recorded in the daily papers reached 16, against an average of 93 per annum for the five years ending 1855, and 32 for a similar period ending 1880. Of the number, 11 proved fatal, no less than 325 persons being killed, the only years exceeding this total being 1857, 1860, 1866, 1877, 1878, and 1880. The disasters involving loss of life were the following:—Jan. 9th, Airdrie, 1 death; February 21, Wigan, 2; March 2, Usworth, 41; April 8, Great Fenton, 6; June 18, Pendlebury, 179; June 20, Chesterton, 9; October 26, Darwen, 1; November 16, West Bromwich, 2; December, 23, Mardy, 82; Maesteg, 1; December 29, Wigan, 1. It will be seen that three of the explosions—Usworth, Pendlebury, and

Mardy—contributed between them 302 deaths. It may, perhaps, be some small satisfaction to compare our own losses with those announced from foreign coalfields during the same period. Of course we only hear of very important disasters, so that the 15 fatal explosions and 550 deaths telegraphed from the Continent and America will fall far short of the actual total. In the year 1884 the deaths at home were only 65, whereas abroad they amounted to at least 420. Looked at from any point of view these figures speak highly in favour of the general excellency of the management of our home mines.

At intervals throughout the year warnings have been published calling the attention of miners to dangers to be appremended from changes of atmospheric pressure. These warnings, which have now been before the public for five years, are based mainly upon the distribution of areas of high barometer readings, or anticyclones. An examination of the occurrence of explosions with the prevailing atmospheric conditions during the past year again favours the results obtained from similar comparisons in previous years. Eleven out of the sixteen explosions were accompanied by a higher or rising barometer, while with the remaining five the mercury was low or falling. To the former may be added a serious outburst of gas at the Monk Bretton Colliery, from January 13th to 16th, necessitating the withdrawal of the men from the workings for about three days. These facts indicate that if lives are to be saved, and the number of explosions still further reduced, all persons having anything to do with underground workings must sacrifice the very popular idea that a low or falling barometer is the only time when gas becomes dangerous and explosions are likely to occur. Let us consider some of the events of the past year, and then refer to elaborate series of observations specially made in connection with atmospheric changes and the appearance of gas in mines.

On the morning of January 10th a very rapid fall of the barometer was advancing across the northern districts from the Atlantic, when a drawer at the Whitebrick Colliery, near Blackburn, opened his lamp to give another workman a light, and the gas immediately fired. There were over eighty men in the workings, but only the three persons near the seat of the explosion were injured; the workings

were set on fire, and the men had to be withdrawn. According to a local account, "the explosion was a comparatively slight one, and the report not loud enough to alarm the neighbourhood." The disturbance passed away and the mercury rose quickly. Two days after the rise commenced, the increase of gas in the Monk Bretton Colliery made it necessary to cease working, the barometer continuing to rise until the 19th. During the month of February the barometer over the whole country was unusually low, the average height for the month being one-third of an inch below the mean of previous years. The only considerable rise of the mercury was accompanied by the loss of two lives near Wigan, on the 21st. No accidents were reported while the great deficiency of pressure prevailed. The last day of the month brought another brisk increase, which formed a large anticyclonic area over the north and east districts during March 1st and 2nd. Towards the evening of the 2nd the centre of highest pressure was moving eastward, into the North Sea, and at 9 p.m. took place the Usworth explosion, the barometer over the locality at the time being at 30 inches, and beginning to fall moderately fast. Again, on the night of June 17th a brisk rise came up from the south-west across Wales, and by the morning of the 18th the rise had extended to the North of England. Shortly after 9 a.m., when the barometer was about reaching its maximum, the most disastrous explosion of the year occurred, 179 lives being sacrificed at the Clifton Hall Colliery, Pendlebury. It should be noted that after the explosion earthquake shocks were felt in several parts of Yorkshire, but whether there was any connection between them it is impossible to say. Shocks of earthquake were felt in different parts of the north during the next two or three weeks. Coming down to Christmas, we find that on December 22nd a rapid rise was in progress, and on the 23rd a large area of high barometer had formed over Wales and Ireland, the readings over South Wales reduced to sea level being nearly 30·7 inches. It was under these conditions that we have recorded the loss of 82 lives at Mardy and one at Maesteg on the same day.

These instances of actual explosions suffice to indicate to us by the very similarity of their accompanying atmospheric changes that greater attention must be devoted to areas of high barometer in con-

nection with the management of collieries. Still more does this become apparent when we come to deal with the very complete series of hourly observations carried out under the supervision of Mr. V. W. Corbett, in the workings of Seaham Colliery after the disaster of September, 1880. The observations extend over a period of several months, and the diagrams show at a glance that the gas-check indicated an increase of gas with any important increase of atmospheric pressure. The barometer at the surface, and two others in different parts of the workings, agree in their fluctuations, both as regards the time and the amount of the changes. The Maudlin Seam had been carefully sealed up, so as to have no connection with the outside atmosphere. The variations of pressure in this hermetically sealed chamber were recorded by water gauges, which showed that gas was escaping while the barometer was rising, and long before any decrease of pressure had set in. The seeming contradiction of the law of pressure on gasses led Mr. Corbett to the conclusion that the barometer is very tardy "in denoting the fluctuations of atmospheric pressures," even as much as 33, 35, 41, and 48 hours late. Were this a fact charts of synchronous observations of wind and barometer would present a strange peculiarity, viz., that the atmospheric circulation indicated by the winds would sometimes be more than 2,000 miles in front of the position shown by the barometer, a circumstance not yet recorded in any country, and never will be. The water-gauge and barometer indications were for two distinct elements, so that the action of the one need not accord with the action of the other in every particular. As, however, water-gauges are not in common use, we have to content ourselves with the instruments which are, and there seems to be no doubt that, whether we take into consideration the conditions of atmospheric pressure shown by the ordinary barometer over a tract of country at the time of explosions, or the excellent series of local observations by Mr. Corbett, we are forced to the conclusion that gas becomes dangerous while the barometer is rising and long before there is any indication of a decrease of pressure. Further proof of this has been discovered in the investigations which have followed upon the great explosions in Austria within the past eighteen months. One of the conclusions arrived at in the report on the

observations at the Karwin mines is "That where, after a rapid rise of the barometer, it continued to rise slightly, or remained stationary for some time at its maximum, a gradual increase in the volume of gas in the air would set in; or if, after a rapid fall in the barometer, it continued to fall gradually, or remained stationary at its lowest point, a decrease in the quantity of gas would become apparent." The results of the two distinct series of observations at Seaham and Karwin completely justify the system adopted in the colliery warnings before the observations were commenced.

The question naturally arises—How are we to explain the seeming contradiction of the laws of pressure on gasses? A year ago it was suggested that the real explanation will probably be found in the supposition that the earth's thin crust feels the changes of atmospheric pressure, the undulations, perhaps, being very slight of themselves, but sufficiently marked to affect the presence of gas in faults and other reservoirs at no great distance from the surface. We know that a rise of one inch in the barometer causes the surface of the sea to be depressed a little more than one foot. Japan feels many earthquakes during the year, but the great majority of them take place in winter when the barometer is high, not one-third of the shocks occurring in summer when pressure is low.

Finally we come to the question of coal-dust. It is now generally recognised by those who have studied the subject that the severest explosions occur in dry, dusty mines, the impalpable dust particles floating in the air being a means of propagating an explosion to long distances from the seat of origin. Now, if we consider the matter, it will be admitted that so far as this element of danger is concerned, an anticyclonic distribution of pressure favours greater violence in explosions from the fact that, generally speaking, a high barometer accompanies a dry atmosphere, which would render the coal-dust more inflammable than with dampness. It becomes necessary, therefore, to impress upon colliery officials both gas and dust become dangerous many hours, sometimes days, earlier than is generally accepted.

It is, perhaps, a little risky to make any prediction as to the future, but it is interesting to notice in the following table that,

taking the number of explosions recorded every five years from 1851, and the average number of deaths in each, the natural conclusion to be arrived at is that 1886-1890 will show a decrease in the number of explosions, but an increase in the average deaths exceeding that for 1876-80.

	1851-5	56-60	61-5	66-70	71-5	76-80	81-5
Explosions	464	356	290	275	243	162	123
Average deaths... ...	2·5	3·6	2·9	5·6	4·0	10·4	7·2

The averages are alternately low and high. It certainly looks as if the period we have now entered upon will have a very high average death rate. It is to be hoped that extended knowledge will not only reduce the number of explosions but also provide such means as will prevent the greater sacrifice of life.

ON SOME REMAINS OF FOSSIL TREES IN THE LOWER COAL MEASURES AT CLAYTON, NEAR HALIFAX. BY JAS. W. DAVIS, F.G.S. (THE PHOTOGRAPH).

The PHOTOGRAPH issued with this volume of proceedings represents a remarkably well-preserved example of the base of the trunk and the attached roots of a fossil tree found whilst baring the Elland flagstone in the Fall Top Quarries, at Clayton, by the proprietors, Messrs. John Murgatroyd & Sons. The fragmentary remains of numerous examples have been repeatedly found on the same horizon whilst clearing away the raggy stone and shale which overlies the flagrock to a depth of about 20 feet below the surface. The bole of the tree rises three or four feet from the level on which the roots are almost horizontally extended. Its upper surface is flat and horizontal, the diameter across is 3 feet 9 inches. The under part divides into four principal roots, each subdivided into two, and these again at a variable distance from the parent stem bifurcate and form still smaller rootlets. The primary roots varying from 1·5 to 2·0 feet in diameter, which rapidly diminishes after each bifurcation. The greatest length that has been exposed from the centre of the trunk to the extremity

of the root is 16·0 feet; if the smaller roots could have been traced they would no doubt have been found to extend to a much greater distance. The roots are all within a few inches of being on exactly the same horizon, a somewhat remarkable fact which appears to indicate that the bed beneath the one of shale in which the tree grew and flourished was more or less indurated before the growth of the trees, and offered resistance to the downward tendency of the roots. The tree in due course died, and the stem decayed down to the level at which it was embedded in the clay or earth in which it grew. The hollow stem became filled with sand and clay, and eventually the whole of the woody tissue was replaced by mineral matter, and a more or less exact representation of the original tree was formed, and has been preserved. Examples of comparatively recent date may be frequently seen in swampy districts, in which the roots and boles of trees are found, the latter decayed down to the level of the surrounding mud, and similar examples in the peat on the neighbouring hills are not uncommon in which the stump and roots of the trees are preserved exactly as in the ancient carboniferous fossil.

A photograph of the somewhat similar stem of a tree found at Wadsley, near Sheffield, was issued with the proceedings of the Society for the year 1876, a short description of the fossil being given in that year's proceedings (vol. vi. p. 179), and also in the Quarterly Journal of the Geological Society, vol. xxxi. p. 358, the latter contributed by Dr. H. C. Sorby, F.R.S. Previous to the discovery of these examples, numerous observations had been recorded of fossil trees occurring in the coal and the sandstones of carboniferous age in various parts of the country. Mr. E. W. Binney (Phil. Mag. vol. xxiv., p. 165, etc.), has given the result of his investigations in the coal fields of Lancashire. Mr. Henry Beckett (Quar. Journ. Geological Society, vol. i. p. 41) describes the stems and roots numbering seventy-three in an area of a quarter of a mile. They occurred in an open working of the coal in Parkfield Colliery, Wolverhampton. Mr. W. Jek (op. cit. p. 43), also contributes a paper on these remains, in which he describes the section stating that in beds 12 feet in thickness there are three beds of coal, and that each of them on its surface exhibits the remains of a

forest of large trees. In each instance the evidence shows that the trees grew and perished on the spot where the remains were found, their roots still fixed in the coal and shale which formed the humus in which they grew. Mr. J. S. Dawes (Quart. Journ. Geol. Society, vol. i. p. 46) furnished an account of a fossil tree found in the coal grit near Darlaston, South Staffordshire. It was 44 feet in length, extended horizontally with several branching stems. The substance of the tree differs from the surrounding sandstone, being hard and fine grained and impregnated with iron. The author states that he has obtained some excellent sections of the wood "which show that the structure is remarkably perfect, and prove the tree to have been coniferous." It very rarely happens that the structure of trees found in sandstone or grit have any structure preserved, and this example is all the more remarkable on that account. At the Wadsley Asylum the tree stumps already referred to were about 10 in number, in an area about 40 or 50 yards in length. The largest and best preserved specimen is about 5 feet in diameter, and, like the specimen at Clayton, its upper surface is a flat as if it had been cut across. It has eight large roots which, when they can be traced for a sufficient distance, are seen to bifurcate. The longest extension of the roots is about 6 feet, beyond which they are either hidden in the matrix or have been destroyed. In addition to the roots there are one or two prostrate trunks. The larger specimens are stated by Dr. Sorby to have eight roots; the smaller ones, probably immature, being possessed of only four. A curious circumstance also noted as "one of the most interesting facts connected with these trees is the evidence they furnish with respect to the direction of the prevailing winds at the time they grew. A careful examination of the trees now growing on the exposed moorland hills of the district shows that when they are young the prevailing westerly gales often make them incline to the east; and in doing this, the roots on the west side are pulled straight and made to run more horizontally whilst those on the east side are pressed down and made more nearly vertical; and these characters remain permanently when the tree has grown to a large size. Now this sort of difference on different sides can be recognized more or less decidedly in the case of all the

stumps seen in the Wadsley fossil forest, but is especially well-marked in the largest and best preserved specimens; and it appears to me a very interesting fact that the direction of the prevailing high winds at the carboniferous period thus indicated is almost exactly the same as that at the present period, as shown by the same facts seen in trees now growing in the neighbourhood."

Some years ago, during the excavations in making the G.N. line of railway from Halifax to Bradford, the trunk and roots of a fossil tree were discovered near Queensbury, at a much lower level than the Fall Top Quarries, but on the same horizon, the strata being thrown down by a fault. The specimen is very perfect; it was carefully excavated, and presented by the Engineer, Mr. Frazer, to the Yorkshire College, at Leeds, where it may now be seen. It is smaller than the specimen now photographed, and the roots do not extend greatly beyond the diameter of the trunk: they exhibit, however, very clearly the quadrate division of the base of the trunk into roots, which extend from it almost horizontally. The larger example, recently discovered, had also four principal roots, but the bifurcation of some of these is so rapid as to give the appearance of a larger number. It appears probable from a study of these specimens conjointly that the initial roots formed a series of four and that the more aged or larger grown specimens the roots increased in number by bifurcating.

Since the photograph was taken a second example has been found at Clayton, in another quarry closely adjoining, which is larger than the first. The specimen photographed has been purchased by Prof. W. C. Williamson, F.R.S., and removed to Owen's College, Manchester.

NOTES ON ANCIENT COAL MINING. BY T. W. EMBLETON, ESQ., M.E.

The beginning of coal mining, like most other things, is enveloped in the obscurity of the past. There is little doubt that coal, so far as can be gathered from scattered notices discovered here and there in various records, was first obtained by manual labour from the outcrops on hill sides or the margins of brooks and rivers, or the cliffs of the sea coast. In such places the attention of the ancient people would be arrested by the contrast of the black mineral with the colour of the superincumbent and the adjacent strata. The use of coal and other mineral substances did not become general until the necessity for their use became apparent, nor were they at first extensively worked. In ancient British and Roman times coal could not have escaped the notice of the energetic people of the land, though the forests that then covered the greater part of England afforded abundant supplies of fuel. The Romans, as we shall see, had discovered coal and its uses, or had derived their knowledge from the Britons. In Anglo-Saxon and in Norman times, as manufactories of various kinds were established and increased in number and extent, the forests suffered in proportion.

The iron and glass works which were carried on extensively in the northern and eastern parts of England consumed increasingly enormous quantities year by year; the forests diminished, and the use of wood as fuel became more and more costly. This destructive process had the effect of directing public attention to the acquisition of mineral fuel for manufacturing and domestic purposes, and hence the excavation of coal rapidly increased; but it was only after the invention of the steam engine that the demand and supply enormously expanded, and has now attained dimensions which a century ago would have been deemed fabulous and altogether increditable.

In the Saxon Chronicle of the Abbey of Peterborough there is the following passage: "About this time," A.D. 852, "the Abbot Coelred let to hand the land of Sempringham to Wulfred, who was to send to the monastry 60 loads of wood, 12 loads of coals, and peat and other things."

Whether the meaning of the Saxon word is coal, as now understood, is subject to some doubt. The original words are "twælf fothur Græfan" (ie. 12 fothers of coal, about 15 cwts. each). In A.-S. this word (Græfa) may mean anything that is dug up. It is evident that Græfa was a different fuel from peat. There is no A.-S. for peat which is English only. The old British name is said to be Glo; the Welsh has Pwll Glo, Pit-coals. In Bosworth's A.-S. dictionary, Græfa is coal.

Coal is in Middle Eng., Col; Dutch, Kool; Icel. and Swed., Kol; Dan., Kul; Old High Germ., Chol, Cholo; Middle High Germ., Kol; Mod. Germ., Kohl. The French houille, only wants an aspirate to assimilate it to the northern word.

From Pennant's Tour in Wales, he states that a flint axe, the instrument of the aboriginals of our islands, was discovered sunk in certain pieces of coal exposed to day in Craig y Lare, in Monmouthshire, and in such a situation as to render it very acceptible to the unexperienced natives who in early times were incapable of pursuing the seam to any material depth.

Whittaker, in his History of Manchester, is of opinion that the primæval Britons used coal. This is evident, he says, from its appellation amongst us at present, which is not Saxon but British, and subsists amongst the Irish as their Guel, and amongst the Cornish in their Kolan to this day. In the great survey (the Domesday Book), carried out by William the Conqueror, there is no mention of coal or any other minerals. No instructions were given to the Commissioners to enquire into the extent and value of the mineral property of the central or northern counties. Strutt states that in opening some mounds in 1773, near Maldon, in Essex, bones, cinders, and charcoal were found; this he relates in his Book of Manners and Customs, Vol. 1, p. 60.

Marston, in his Natural History of Northamptonshire, speaking of the ruins of a castle at Castle Dykes, a high, entrenched hill, near Farthingstone, says he saw some huge lumps of cinder. This castle is supposed to have been built by Æthelfleda, about 913, it was destroyed by the Danes in 1013. and he concludes that there were stores of coal kept there. St. Augustine says, "is it not a wonderful

thing that though coals are so brittle that with the least blow they break and with the least pressure they are crushed into pieces, yet no time can destroy them, inasmuch that they who pitch land-marks were wont to throw them underneath to convince any litigious person who shall affirm, though ever so long after, that no land-mark was there."

In Ireland coal was worked at an early period, as the following statement proves, although no precise date can be assigned for the work. At Ballycastle, in 1770, in a passage cut through one of the seams these old workings were entered, they were narrow, their sides were encrusted with sparry-like matter. This discovery led to a gallery which had been driven forward for several hundred yards. It branched into thirty-six chambers. The coal had been worked in a regular manner, pillars being left to support the roof. The remains of tools and baskets were found in the workings, but there is no statement of the kind of tools. Near Stanley, in Derbyshire, some years ago, some colliers driving in the Kilburn coal, broke into some old excavations, in which they found picks made out of solid oak. These implements were entirely destitute of metal, and were cut out from one solid piece of timber. Implements belonging to an equally early period are stated to have been found in old coal workings near Ashby de la Zouch, consisting of stone hammer heads, wedges of flint, with hazel withes round them, and also wheels of solid wood.

The Romans were acquainted with the use of coal. They had stations in places near the outcrop of coal seams, and coals and cinders have been found in the Roman towns and villas. Wigan, in Lancashire, was a Roman station. Not far from that town, a bed of coal, known as the Arley Main, crops out on the banks of the river Douglas. While driving a tunnel to divert the course of this river, the Arley seam, 6 feet in thickness, was found to have been mined in a manner hitherto altogether unknown. It was found to have been excavated into a number of polygonal chambers with vertical walls, opening into each other by short passages, and, on the whole, presenting a ground plan something of the appearance of a honeycomb. The chambers were regular both in size and form over an area of at least 100 yards in one direction, and were altogether

different from any modern mining in the district. The arrangement and regularity of the work were peculiarly Roman, resembling in some measure their tesselations, or the ground plans of their baths and villas.

Whittaker, the historian, of Manchester, relates that in the West Riding of Yorkshire a quantity of Roman coins were found among many beds of coal cinders heaped up in the adjoining fields. These "coal cinders" were found to be slags from ancient ironworks. I have not yet found any notice of early coal working in Yorkshire. Mr. T. Wright considers that the Shropshire coal field was discovered by the Romans—not far from the borders of this coal field stood the antient Uriconum now Wroxeter. During the excavations considerable quantities of coal, both in the raw state and partially consumed, were found; it had been used apparently in heating the ovens.

It is stated that coal was discovered in Begium, near Liège by a pilgrim in the year 1189.

In the survey of Hugh Pudsey, Bishop of Durham, called the Boldon Buke, made in the year 1183, which may be called the Domesday Book of that county frequent mention is made of coal. The survey was made for the purpose of ascertaining the revenues of the whole bishoprick as they were then and the assized rents and customs as they then were and formerly have been. The following extracts will suffice:—

1. A certain collier holds one toft and one croft of four acres and finds coal for making the iron-work of the ploughs of Coundon.

2. The Carpenter at Wearmouth, who is an old man, has for his life 12 acres, for making ploughs and harrows. The Smith, 12 acres for the ironwork of the ploughs and harrows, and coal which he wins.

3. In Sedgefield.—The Smith, one oxgang for the ironwork of the ploughs which he makes, and he finds coals. The Carpenter, 12 acres for making and repairing the ploughs and harrows.

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1. Text.—Quidam Carbonari tenet j toftum et j croftum et iv. acras et invenit curbones ad ferramenta carucarum de Coundona.

2. Carpentarius qui senex est habit in vitatua xij. acras pro carucis et hereis faciendis. Faber xij. acras pro ferramcutis carucarum et carbonem quem invenit.

3. Faber j bovatum pro ferramentis carucarum quæ facit et carbonem invenit. Carpentarius xij. acras pro carucis et hercis faciendis et reparandis.

The customs mentioned in these extracts appear very curious, that the Carpenter and Smith should be rewarded for their materials and labour in making and repairing the ploughs and harrows, in consideration for a grant of land. Money no doubt was very scarce amongst the farmers and villagers of this period.

In the Magnus Rotulus recept., Dunelm Anno Antonii Episcopi xxv., there are the following entries:—

"Minera Carbonum. Et de 12s. & 6d. de Minera Carbonum in quarterio de Cestr." (Chester le Street).

"Termnius Sancti Cuthbertiin Septembri."

"Minera Carbonum. Et de Minera Carbonum 12s. & 6d. de Minera Carbonum in quarterio de cestr." (Cestria).

It would appear from these notes that the coal must have been worked in the neighbourhood of Chester-le-Street before the date of the above payments.

At Lanchester, in the County of Durham, on exploration in the Roman station, the calcareous flooring of the baths was found to be mixed with coals and cinders. In the foundation of a circular Roman building, on the side of the Watling Street, about three miles south of Ebchester, coals and cinders were found buried together with a smith's hammer.

In Bishop Hatfield's Survey of the Manor of Colliesley, in 1333-1335, the Bishop appoints a supervisor of his mines there. His successor makes a similar appointment in 1384. A coal mine is mentioned in the ordination of the Vicarage of Merryton, in the County of Durham, in 1343, and in 1354 there is extant a notice of the sinking of pits at Ferryhill, in the same County.

If we refer to the coal mining in Northumberland, we find more copious notices of it than in any other County. On 1st Dec., 1239, King Henry III. granted a Charter to Newcastle to dig coals and stones in the common soil of that town, in a place called the Castle Field (now the Town Moor) and the Forth. This is the earliest known date when permission was given to work coals at or near to Newcastle. It is evident that at that time the minerals belonged to the king and not to private persons. In fact the whole place belonged to the king then.

In 1330 the Prior of Tynemouth let a colliery called Heygrove, at Elstwick, for £5 a year; another colliery, also belonging to the Prior, in the East Field, was let for six marks a year; besides which he had one in the West Field, and another near Gallow Flat in the same estate in the years 1331-1334. Two men were drowned in the Gallow Flat Pit in May, 1658, the bodies were not recovered till 24th April, 1695, having lyen in the water for thirty-six years.

About 1333, Philippa, queen of Edward III., had estates in Tynedale, where she long resided during Edward's stay in his campaigns in Scotland, and obtained a grant from her husband to work coal mines there.

Licence was granted to the Burgesses of Newcastle to dig coals and stones in the Castle Field, in 1351. On the 10th May, 1357, King Edward III. granted license to the men of Newcastle to work coal in the Castle Field and Castle Moor. He issued orders concerning the regulation of coal measures. At this time coals were also worked at Gateshead, on the opposite side of the river Tyne. This king gave permission for coal won in the fields of Gateshead to be taken across the Tyne in boats to Newcastle, in consideration of the owners complying with the usual customs of the port. After paying these dues, permission was given that the coal might be sent to any part of the kingdom, either by land or water, but to no foreign country except to Calais, which was then an English port. In this year coal was exported to London from Newcastle.

As in the County of Durham, so in Northumberland, coals had been worked by the Romans during the construction of their celebrated wall.

In 1762, when in digging up the foundations of the Roman station at Caervorran or Magna, some very large coal cinders were turned up, which glowed in the fire like other cinders, and were not known from them when taken out.

At Habitancum (Risingham) near to a spot where traces of a furnace were noticed, more than a cart-load of coals were found, which Mr. Shanks removed and used in his own grate.

At Walton House station, several rooms were found the floors of which, consisting of thick masses of strong cement, were supported on

pedestals. There were many other curious floors found among the ruins, and some coal ashes.

When, in 1833, the eastern gateway (of the Station Cilurnum, The Chesters) was freed from the rubbish that then encumbered it, its eastern portal was found to have been walled up, and converted into a separate appartment, on the floor of the chamber thus formed there was found a cart-load of fossil coal.

The following extract is from the "Roman Wall" by the Rev. J. Collingwood Bruce, L.L.D., &c. "When the lower reservoir of the Newcastle Water Company, in the neighbourhood of South Beuwell (the Condurcum of the Romans) was formed in 1858 some ancient coal workings were exposed, the author examined them, and though he and those whom he consulted saw no reason to suppose that they were not Roman, no coin, lamp, or shred of samian, was discovered to give authority to the conjecture. The seam of coal was two feet thick. It was wrought by shafts sunk to the depth of twelve or fifteen feet and at a distance of forty or fifty-five yards from one another. Lines of excavation radiated in every direction from the bottom of the shafts. The coal crops out on the bank between the workings and the river Tyne so that the mine could be drained by means of an adit.

The instances of ancient coal mining given above were in seams which outcropped on the banks of the river Tyne, and were drained by adits. Leland, in his Itinerary, has the following passage:—"The vaynes of the se coles ly sometyme upon clives of the se, as round about Cocket Island and other shors, and they as some will be called se coals, but they are not so good as the coles that are digged in the upper part of the lande."

Under the term "Sea Coal" a considerable trade was established with London, and it became an article of consumption then. However an impression arose that the smoke arising therefrom contaminated the atmosphere and was injurious to the public health; and it is said that the nice dames in London would not come into any house or room where sea coals were burned, or willingly eat of the meat that was either sod or roasted with sea coal fire.

The subsequent extracts from Harrison's Description of England

prefixed to Hollingshead's Chronicle, edited in the year 1577, contain some very curious and interesting notices concerning the coal trade and his opinion of the use of coal.

"Of cole mines we have such plenty in the Northern and Western parts of our island as may suffice for all the realme of Englande. Sea cole will be good merchandise even in the Citie of London, wherunto some of them alreadie have gotten readie passage and taken up their mines in the greatest marchaint's parlers."

This quaint writer goes on to contrast the manners of former times with his own, "Now we have many chimnyes, and yet our tenderlings complaine of rewmes, catarres, and posers; then we had none but reredoses, and our heads did never ake. For as the smoke of those days (wood) was supposed to be a sufficient hardning for the timber of the house, so it was reputed a far better medecine to keep the good man and his family from the quacke or pose, wherewith, as then very few were acquainted."

"There are old men dwelling in the village where I remain have noted the number of chimnyes lately erected, whereas in their young days there was not above two or three, but each one except great people made his fire against a reredosse in the halle, where he dined and dressed his meat." He further complains:—"When our houses were builded of willowe, then we had oken men; but nowe that our houses are come to be made of oke, our men are not only become willowe, but a great many altogether of straw, which is a sore alteration."

We see that the complaint is not new in 1886, for it is still said that the last generation was better than the present.

In 1306 the complaint became so general that the lords and commons in parliament assembled presented a petition to King Edward I., who issued a proclamatiou forbidding the use of this fuel and ordering the destruction of furnaces and kilns of all who should persist in using it. This prohibition was repeated at several subsequent periods. The use of coal in London was resumed a few years after its prohibition by the King in 1306, as we find in the "petitiones in parliament" in 1321-2 a claim was made for ten shillings on account of coal which had been ordered by the clerk of

the palace, and burnt at the King's coronation, but the payment for which had been neglected. However, owing to the scarcity and dearness of wood, coal was as it were forced into use in spite of proclamations, and prejudice gave way as the value of fossil coal became more known, and from that time its use became more extended. In the reign of Queen Elizabeth the coal trade flourished greatly and was regarded as an important source not only of local but national revenue by succeeding monarchs. In the reign of Charles I. coal was used all over the kingdom.

THE CAYTON GILL BEDS. BY REV. J. STANLEY TUTE, B.A.

Immediately underlying the Plumpton grit, there occurs a bed of highly fossiliferous rocks, traceable from the western boundary of the Permian beds to the flanks of Great Whernside; and from the banks of the Laver near Ripon, to Follifoot, South of Harrogate. In the maps of the Geological Survey it is called the shell-bed, but unfortunately it has no special colour whereby it might be traced. In his memoir of the Harrogate district, Mr. C. Fox-Strangways, adopted the term Cayton Gill Beds, which had been suggested to him, in consequence of an excellent section occurring in the little valley called Cayton Gill, about three miles North-West of Ripley. Here the beds dip 20° south under the Plumpton rocks, and rest conformably upon a bed of very dark shale, slightly fossiliferous, on the east side of the hill, but half-a-mile to the west, on the other side of the hill, abounding in Poseidonomya becheri, a small orthoceras, some fishes' teeth and scales, and vegetable remains.

The upper parts of the Cayton Gill beds are much softer and arenaceous than the lower, which are very hard, and in many places are quarried for road material, as at Hampsthwaite, Follifoot, Darley, and near Fountains.

The occurrence of these fossiliferous beds in the middle of the millstone grit series, commonly so wanting in organic remains, seems to me to possess a certain value as a horizon in the midst of a dis-

trict very greatly disturbed by faults, which are concealed by pasture and arable land. It would be an advantage, therefore, I think, if they could be distinctly marked by some special colour in the Geological maps of the district, and not concealed under the general colour for sandstone. The fossils generally occur as casts, sometimes filled with carbonate of iron, and often highly interesting, as they preserve the muscular impressions, &c., with great delicacy. In the land near Fountains, where the rock is exceedingly hard, the shell structure of brachiopoda is beautifully preserved, but the shells of Bellerophon costatus have become porcellanous. Here, as in some other places, the beds are filled with the broken stems of encrinites.

The fossils which I have noticed are as follows :—

Scales of Acrolepis.
Teeth of Cladodus.
Teeth of Petalodus.

Portion of Encrinite Stems.
Producta semireticulata.
,, cora.
,, aculeata.
Spirifera trigonalis.
,, striata.
,, lineata.
Streptorhynchus crenistria.
Orthis resupinata.
,, Michelini.
Chonetes Hardrensis.
Discina.
Aviculopecten.
Bellerophon costatus.
Discites sulcatus.
Nautilus. (Found at Hungate Gill, by Mr. Ingleby.)
Gasteropods.
Conchifers.

Outcrops of these beds occur in the following places :—

1. In the Parish of Bishop Thornton.

Cayton Gill.
Tinker's Lane.
Church Yard.
Ridsdale's Quarry (Watergate).
Stream, East of Careless House.
Raventofts.

2. Near Brimham Rocks, East and South.
Near Clint.
Near Hartwith.
Rivers hill.
Brimham Lodge.
Summerfield's Farm.
Lurkbeck.
Warsill.
Summer Bridge.

3. Near the Parish of Sawley.
Lane from Fountains to Sawley.
Spa Gill.
Hungate Gill.
Near Eavestone Lake.
North Pasture.

4. Near Pateley Bridge.
Ripon and Pateley Road, near Pateley.
Bleasefield, near Glasshouses.
Old Lane, Scotgate Ash, Bishopside.
Under Guyscliff.
Near Eagle Hall.

5. Constable Ridge, Kettlesing.

6. Near Harrogate.
Follifoot.
Saltergate Hill.
Four-Lane Ends.

ON SAFETY LAMPS. BY ARNOLD LUPTON, ESQ., C.E., F.G.S., PROFESSOR OF COAL MINING, YORKSHIRE COLLEGE.

An unusual amount of attention has been given to safety lamps during the last two years, not only by mining engineers, lamp makers, and other inventors, but by the general public; and, as a consequence of public interest, by the Government through the Inspectors of Mines, and the Accidents Commission; it occurred to me that some brief summary of the results of the experience gained in reference to safety lamps by general usage, by mining institutes, by Royal Commissions, and by individual investigations might not be uninteresting and might possibly afford some instruction. Few things are more striking in engineering history than the occurrence of great inventions just at the moment when the progress in other departments of the arts and manufactures makes such an invention of prime importance, and then the invention, once made, it seems to be complete, and as if no further inventions could supersede it. This is the case with regard to the safety lamp. It was just when the war with France was ended, and we directed the whole of our national energies to the pursuits of peace, when the improvements in the steam engine, and the developement of the factory system and the resulting increase of trade and population called for a large production of coal for iron-making, manufacturing, and domestic purposes, and this large production of coal could only be obtained at a terrible risk and great sacrifice of human life; then it was that the safety lamp was invented and first practically used, just 70 years ago, in 1816. The lamp invented by Sir Humphrey Davy remains to-day in large and general use; thousands of clever men have spent time and money since then in the endeavour to invent a novel safety lamp, but with two exceptions, to which I shall afterwards refer, not one has succeeded; and of these two exceptions, one is only fit for occasional use, and the other has not yet received a practical trial. Many improvements have been made, but these have been in matters of detail, and there is not one single lamp in practical use which is not

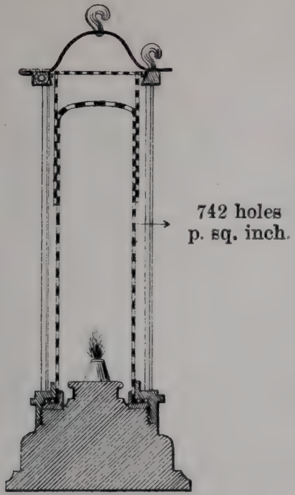


Fig. 1. Davy Lamp, ¼.

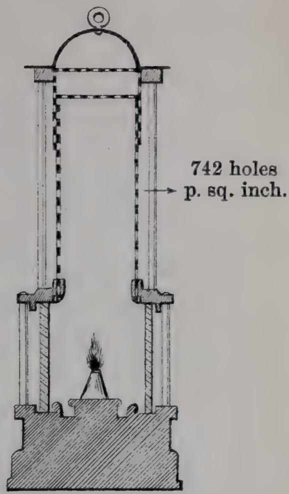


Fig. 2. Clanny Lamp, ¼.

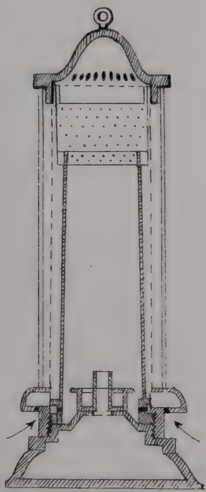


Fig. 3. Stephenson Lamp, ¼.

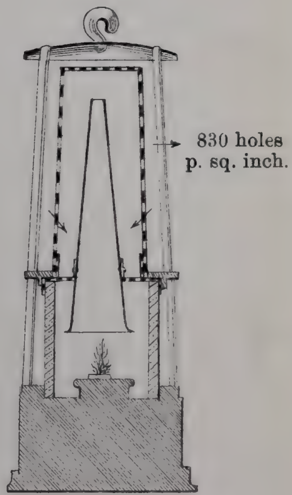


Fig. 4. Mueseler Lamp, ¼.

in effect a Davy lamp, though it may be with improvements added to it.

I do not wish it to be supposed that I ignore the invention of George Stephenson, who invented a safety lamp at the same time that Davy invented his. Stephenson's invention had merit, but the merit was not equal to Davy's, because whilst the Davy lamp is and has been generally used, and is by some, even at the present day, considered to be unsurpassed for general utility, the Stephenson invention has never been practically used, except when put inside a Davy lamp. I will now briefly describe the Davy lamp, as a foundation for the description I propose to give of the various modifications and improvements, to which the time at my disposal will permit me to refer:—The Davy (see fig. 1) is an oil lamp, of which the flame is covered with a wire gauze cylinder; under ordinary conditions flame will not pass through this gauze, it is made of woven wires, the wires about 1-50th of an inch in diameter, and 28 of these wires are laid paralled in an inch of warp, and the same number in the weft. This gauze constitutes a metallic case with perforations, and the case might be made of plate iron perforated with holes, this would make a lamp as safe as wire gauze when in good order, but it would be more easily broken; it would be more costly, and give less light. When flame is brought into contact with the gauze the gas passes through the apertures, but is cooled by the contact with the wires below the point of ignition, so that the flame does not pass; hence a flame inside the lamp does not pass through and ignite gas on the outside; and even when the gauze is very hot the same effect is produced, because the heat of a flame is so intense that very hot wire is cool by comparison. A lamp covered with this wire gauze may be safely carried through a mine filled with an explosive mixture, and may be used to detect the presence of inflammable gas, without danger to the fire-trier. When put into a place containing two per cent. of gas, if the flame is drawn down, a blue cap may be seen over the lamp flame, and the more the gas the bigger the blue cap; but if there is eight per cent. of gas it will explode inside the lamp, but no harm ensues. The lamp has been used by hundreds of thousands of miners without accident, in other cases accidents have occurred.

I will now describe some of the modifications of the Davy, and the first of these is the Clanny lamps (see fig. 2), called, like most other lamps, by the name of the inventor. This only differs from the Davy in having a glass cylinder substituted for the lower part of the gauze cylinder. There are two great advantages gained by this improvement, great increase of light, taking the light of a sperm candle as 100, the Clanny will give 47 and the Davy only 18 (according to Marsaut). The second advantage is that it is easily carried in a strong current of air which would extinguish a Davy lamp. These great advantages have caused the Clanny to be largely used. There are, however, three disadvantages as compared with the Davy: The glass may be cracked and broken if it is heated by holding the lamp on one side or by water falling on to it; it is more complicated and it is an easy matter to put the parts together in such a way that it is unsafe, and yet this may not be detected; 3rd, it is possible to cause an explosion with this lamp if the flame is drawn down for gas trying, and it is raised into an explosive mixture and rapidly withdrawn, an explosion may take place inside which will pass through the gauze and fire the gas outside; this is owing to the glass cylinder holding a charge of explosive gas which is shot out with great violence against the gauze. Such an accident cannot take place with a full flame, because the products of combustion partly fill the lamp and diminish the force of any explosion that may occur; therefore in using a Clanny a full flame should be in the lamp when testing gas.

The Stephenson Lamp (see fig. 3) is constructed by taking a Davy lamp of large diameter, and putting inside it, a glass chimney, on the top of the chimney is a copper cap perforated with small holes; the air for the flame enters the lamp through an external brass ring below the glass, in this ring are perforated small holes, which regulate the current of air entering the lamp, the air then passes through the gauze and under the glass; the amount of air entering the lamp is thus regulated by the openings above and below to the amount required for combustion. If gas enters the lamp it uses up all the oxygen and the lamp is extinguished. This lamp may therefore be put into an explosive mixture and will, under ordinary

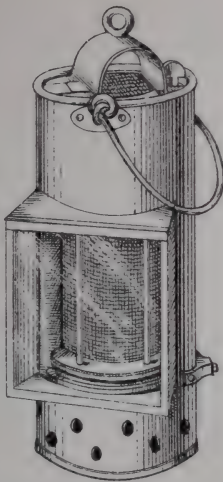


Fig. 5. Davy in Case, ¼.

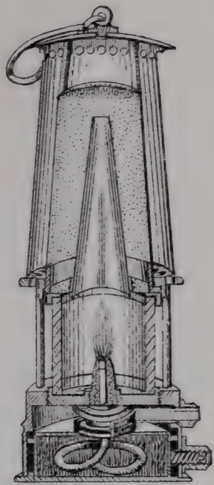


Fig. 6. Section of Patent "Protector" Mueseler with Shield, ¼.

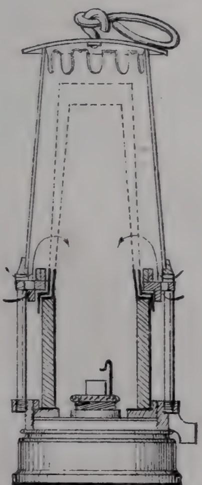


Fig. 7. Marsaut, Section, ¼.

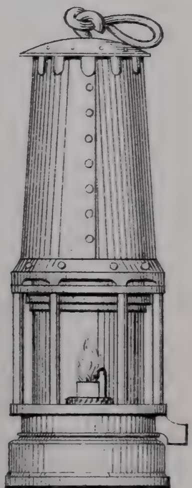


Fig. 8. Marsaut, Two gauze Lamp, with Shield, ¼.

conditions, be certainly extinguished ; and it has happened that all the lamps in a large colliery have been extinguished by a sudden blower of gas filling the mine with an explosive mixture This is an element of safety which the Davy lamp does not possess, and in consequence the Stephenson lamp bas been very largely used ; it gives, however, a worse light than the Davy.

The Mueseler (see fig. 4) or Belgian lamp resembles a Clanny and differs from it only in having a metal chimney and flat gauze diaphragm at the top of the glass. This lamp has two advantages over the Clanny, it is safer, because the horizontal gauze and the chimney constitute minor lines of defence; the chimney is a defence, because it is filled with the products of conbustion through which a flame will not pass under ordinary circumstances. The second advantage is that the lamp is extinguished when put into an explosive mixture, so that in the case of a blower all the lamps in a large mine have been extinguished. The Mueseler lamp has only one fault in the eyes of the workman, and that is that it goes out if held a little crooked. The Mueseler has come into very extensive use because it combines the safety of a Stephenson lamp with the good light of a Clanny. This lamp then seems prima facie to satisfy our requirements, and we will pause to enquire as to what are the circumstances under which it is not safe. The lamp is not safe to use with a reduced flame when testing for gas, as it might cause an explosion, the same as the Clanny, but it is safe for fire-trying with a full flame.

Some of the lamps which I have named are safe in a rapid current of an explosive mixture. Thus if a Davy is in a current of 400 feet per minute, it will explode the gas. A Clanny, a Stephenson, and a Mueseler may explode the gas if the speed is 600 feet per minute. It very rarely happens that an explosive mixture travels through a mine at the speed of 400 or 600 feet per minute, but it often happens that a lamp is carried or moved at a very much greater speed, and therefore it is desirable to have a lamp that is safe at any speed. A man may travel as fast as a mile in ten minutes or 500 feet per minute, and he may meet a current going at an equal speed, the current would, therefore, strike the lamp with a velocity of 1000

feet; if we take a very extreme case, the man might travel on a good road 750 feet per minute, and meet a current of 1500 feet, making a total speed of 2250 feet; to be perfectly safe, therefore, a lamp should be capable of resisting this velocity for some time, but if, in addition to running against the wind, the man should swing his lamp violently, it would be brought against the air at a very much greater velocity. It is difficult to say at what speed a lamp might be swung. I find that I can give a three pound lamp 120 swings of five feet in a minute, making an average speed of 600 feet a minute, and it is probable that the maximum speed of swing exceeds this by half, making a speed of 900 feet, this 900 feet added to the previous velocity of 2,250 feet, makes a total of 3,150 feet. But this is only instantaneous, say a third of a second, because the backward swing of the lamp reduces the speed of current, so that a lamp ought to resist 3,150 feet for a third of a second, and 2,250 feet for a long period, say seven minutes. It must be remembered that the swing of the lamp might happen after it had been exposed for a long time to a rapid current. It may be worth while to consider if the conditions often occur in which a lamp is subjected to a rapid current of an explosive mixture; the history of our coal mines gives a negative reply, it can only happen under one of three circumstances, as follows:—

1. A very badly ventilated mine, where the return air course was foul to the explosive point, a condition of things almost, if not quite unknown in the last twenty years.

2. A sudden issue of gas from stalls between pillars, caused by a large fall of roof; a species of accident of exceedingly rare occurrence.

3. A sudden outburst of gas from the roof or floor of the mine, so powerful as to foul the main air courses to the explosive point; this is also not a frequent occurrence, but is a more frequent cause, taking the last twenty years, of the fouling of a colliery than any other. I do not know the number of such outbursts, but probably in Yorkshire alone there is more than one every year, and perhaps two or three. If such an outburst happens and there is any exposed light on the return air side of it, an explosion will happen; sometimes the intake is also fouled.

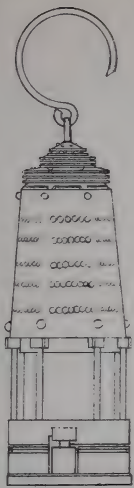


Fig. 9. Morgan Lamp, $\frac{1}{5}$.

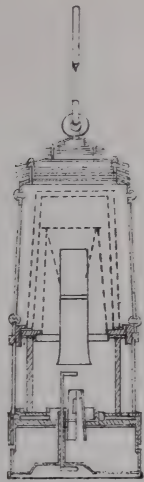


Fig. 10. Morgan, Section, $\frac{1}{5}$.

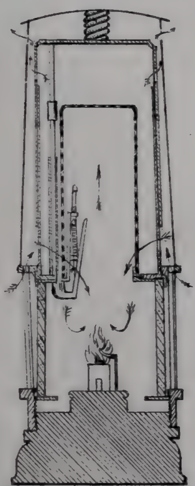


Fig. 11. Evan Evans, $\frac{1}{4}$, with Automatic "Shut off."

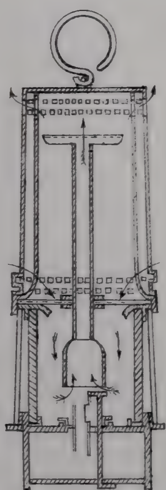


Fig. 12. Clifford Lamp, $\frac{1}{4}$.

It may be taken that the Stephenson or the Mueseler lamp, if well constructed, are safe enough for the general conditions of a mine, and that extra precautions are only required when there is danger of a great outburst. It is, however, difficult to say where this danger does not exist, if we except those mines mostly near the outcrop where firedamp is hardly ever seen; in all the collieries where firedamp abounds in the coal and in the strata there is a possibility of an outburst, and it is to guard against this possibility that the recent inventions have been directed. Having found that the source of danger is the velocity of the air-current, the most obvious cure is to put the lamp behind some shelter,—this is done by putting a Davy lamp into a tin can with a glass plate in front (see fig. 5),—with this protection the Davy lamp from being the least safe becomes one of the safest of all lamps. It has been exploded with a velocity of 2800 feet; it has frequently resisted a velocity of 3100 feet.

The Royal Commissioners consider that it may be implicitly trusted in a current of 2000 feet. But some forms of the tin-can lamp explode at 1200 feet a minute. But this is not satisfactory if we are to be perfectly safe. The next step then is to take the safest of the unshielded lamps, the Mueseler, and to put it in a case that will protect it from an air-current. (See fig. 6.) If this case is properly constructed it makes a lamp that will resist a current of 2400 feet a minute with certainty, and will generally resist a current of over 3000 feet, and if the chimney is very carefully proportioned, and the bonnet also, it is possible that this lamp will resist a velocity of over 5000 feet a minute, and it is in fact absolutely safe. Mr. C. E. Rhodes says that the lamp is safe at 52 feet a second, but I consider Mr. Rhodes' 52 feet is really 104 feet, owing to the contraction of the air-passage by the lamp. There are a variety of modifications of the form of shield, of the chimney, and of the gauze, for some of which is claimed a greater degree of safety, in fact that no velocity will explode them. There is a practical difficulty in testing lamps at high velocities; a considerable force is required to produce the air-current, and large gas-holders. And also, some of the lamps are blown out in the testing-tube before the gas reaches them. In considering how to make a safety lamp, it is natural to reflect that if

one gauze will make a lamp safe, two gauzes would make it safer, and three gauzes safer still. It was this form of reasoning which led M. Marsaut to improve the Clanny lamp, by putting two gauzes instead of one (see figs. 7, 8) and also three gauzes. By this arrangement the lamp is made perfectly safe for fire-trying, but a shield is necessary to make it safe in a rapid current. With a well-constructed shield and two gauzes the lamp is probably safe at 1500 feet, with three gauzes it has resisted trials at a velocity of 3000 feet, and, I believe, 5000 feet.

In choosing a safety lamp the great weight of authority is in favour of having one that gives a good light, and that is, therefore, the first consideration. Therefore it is necessary to have:—(1) glass lamps, and (2) in order that the lamp may be always in good order, the inlet air should not pass through gauze or perforations on a level with the oil-pot, therefore the air must enter the lamp above the glass. Gauze or perforations at the oil-pot level are sure to get clogged and dirty. (3) The colliers and deputies ought to be able to see that all the essential parts of the lamp are in their proper place before it goes into the mine, and for that reason the shield should be removed after using, and before the lamp is given out again it should be examined by the collier and a deputy before the shield is attached. It has always been considered essential in using safety lamps, that they should be examined by the collier and by the fire-man or deputy, and any departure from this rule involves greater risks by far than those now incurred by the use of the common Davy. (4) The lamp should be so designed that when it is put together for use, it cannot be partially opened, without undoing the lock; a great many of the glass lamps in common use are so made that the glass can be loosened so as to entirely destroy the safety of the lamp, and this may be done inadvertently.

Before proceeding further, it may be well to consider the electric light, and it must be admitted that if we are seeking a perfect lamp in order to avoid a risk that may not occur in any mine for thirty years, we must at once regard as inadmissible any light in a mine that causes additional risk. No gas lamp, or any other lamp than the best safety lamp should go below the pit bank, or be within reach

of the mine-air issuing from the upcast top. Therefore the incandescent electric lamp for lighting the porch of the downcast bottom and the upcast pit top, if coal is wound at the upcast, is a great improvement upon gas or paraffin lamps, because the light is in a perfectly air-tight case and no gas can touch it.

The incandescent electric lamp fulfils all the conditions of a perfect lamp; it is destroyed the instant it ceases to be perfect. Perfect as the lamp is, there is a sensible risk in taking it a yard beyond the arching of the porch, because the wires that connect it with the dynamo are a source of danger. If a wire breaks there is a spark, and this would ignite the gas if there was any; and it is doubtful if there is any advantage in the electric light in the porch to compensate for the risk incurred through the conducting wires.

For lighting the working-places of a coal mine a portable lamp only is permissable, several of these have been made varying from 3lbs. to 6lbs. in weight. The 6lb. lamp made by Swan is charged by a dynamo on the bank for a small cost, and it is probable that the only practical objection to some such lamp is the weight; for a collier who stops all day in one place this is not serious, but for deputies, managers, and horse drivers, it is a serious objection, and one that will prevent the general adoption of the 6lb. lamp. The 3lb. lamp has not yet been made to work cheaply, a cost of chemicals alone amounting to one penny a shift is a prohibitory charge. The inventors, however, promise to work it for one farthing a shift. For the present, therefore, the portable electric lamp is only in the experimental stage, and the colliery manager of to-day must use a different lamp. To-morrow, or next year, the portable electric lamp may be perfected.

As soon as we depart from the older types of lamp we encounter new risks; with a Davy lamp we know where we are, we can see if the lamp is in proper condition or not, and if it is well made it is perfectly safe, except under conditions which very rarely arise, but with the new lamps unless a man has seen it put together he cannot tell what he is carrying; it might be a lamp without a gauze, it might be no safety lamp at all, and the man who enters the most dangerous parts of the mine may be trusting entirely to the memory,

care and skill, of some lamp cleaner who has very little experience. For my part I would sooner carry an old Davy lamp than take a shielded lamp which I had not seen put together myself unless I had the assurance of some pitman that he had seen it put together. It has been suggested that safety can be insured by testing the lamps in an explosive mixture every day as they are given out. When I gave evidence to the Royal Commissioners about six years ago, I told them that I did not consider such a system of tests was practicable, and I have seen no reason to alter my opinion. When an imperfect lamp is put in an explosive mixture it may ignite the gas or or it may not; the ignition proves the lamp to be bad, but the failure to ignite it does not prove the lamp to be good. A means of rapidly applying a really searching test, such as a rapid current of explosive gas, in a rapid and practical manner, has not yet been adopted, and if it is ever adopted it will be a rather costly operation. The more common tests of putting the lamp for a few seconds into a box filled with an explosive mixture, or passing it through a ring of gas jets, are absolutely worthless, and the plan recommended by the Commission is very little better. They recommend a vertical tube about eight inches in diameter and two feet long open at both ends, and gas jets at the bottom, so that there may be a constantly ascending current of explosive gas. (See fig. 13.) An imperfect lamp put into such a tube may or may not explode the gas; if it does not explode nothing it proved at all. To illustrate this I have prepared a few experiments:—

1. I take a Clanny lamp with a hole in the gauze $\frac{1}{4}$ inch in diameter, manifestly a very unsafe lamp; I put it into the hole which contains an explosive mixture; the lamp is at once extinguished.

2. I take a Stephenson lamp with a hole about $\frac{3}{8}$ inch diameter, punched through the copper cap of the glass and through the gauze cap, that too is extinguished.

3. I take a Stephenson lamp and remove the glass, leaving it a large Davy, then I punch a hole $\frac{1}{8}$ inch diameter in the side of the gauze, that too is extinguished.

4. Then I take a Shield lamp and omit one of the gauzes, so that there is a straight opening entirely unprotected, and put that into the explosive mixture, that too goes out.

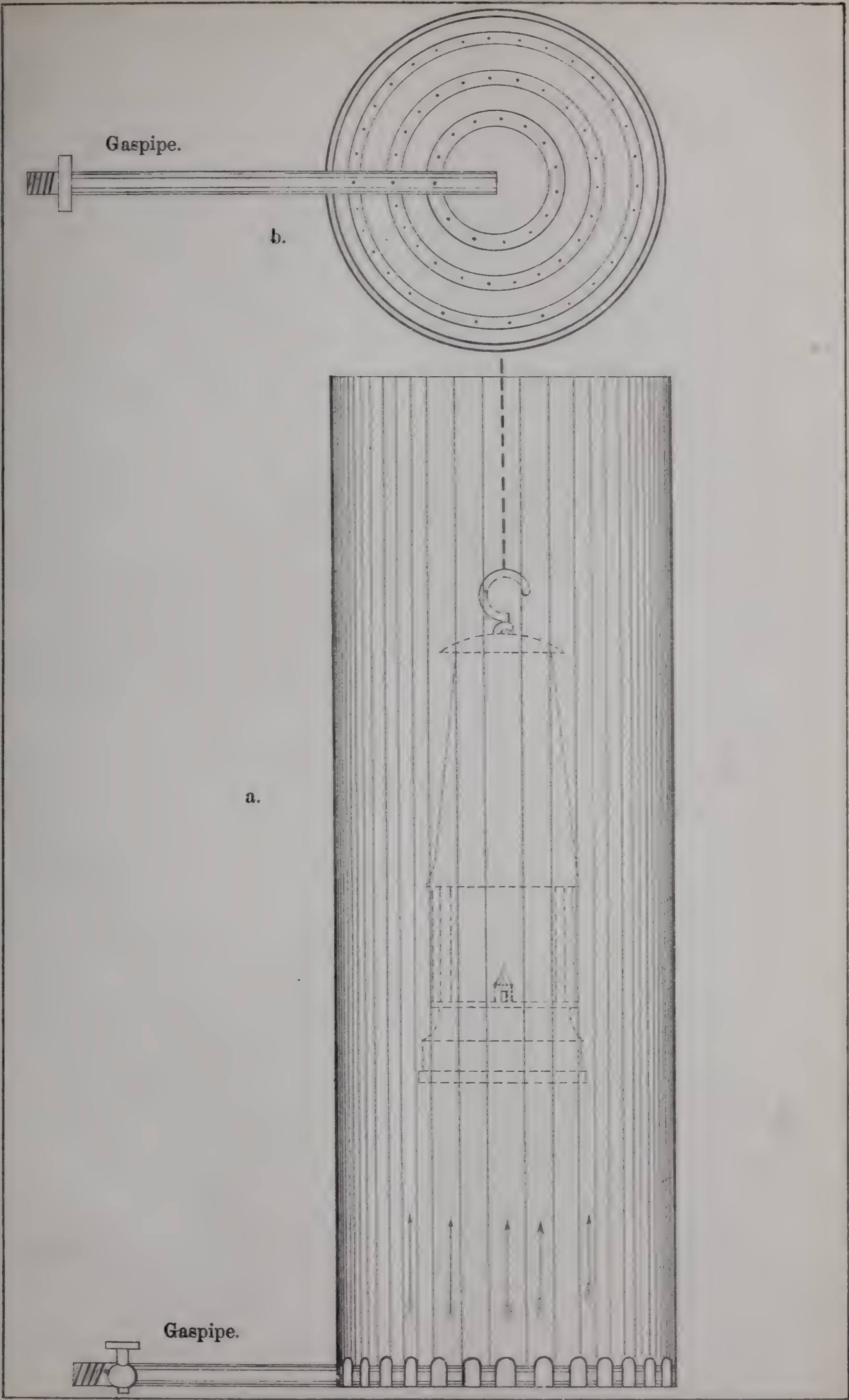


Fig. 13. Testing Tube with gas jets. a. Elevation. b. Plan. ¼.

By the test all these lamps are safe, as a matter of fact, they are all exceedingly dangerous. It is an elementary proposition that an experiment with a negative result proves nothing until it has been repeated a great number of times. One experiment is enough to prove beyond the possibility of doubt that a lamp will explode the gas; it takes a hundred experiments to establish an even prima facie case, or a probability that it will not fire the gas. There is only one mode in which we can make reasonably sure that all the lamps in the mine are safe; and it is this, to adopt a lamp which has successfully passed the heaviest test a thousand times; to make every lamp an exact and perfect copy of this tested lamp; to discard every lamp that is damaged; and every time after a lamp has been used, it must be examined by a competent person to see that it has not been damaged, and every time that the separated parts of a lamp are put together it must be done by a competent person, and the operation must be watched by two other persons, one of whom should be the collier who is going to use it, and the other an experienced deputy or fireman. This involves some loss of time and some expense, on which I remark that the time is only a minute spent by the collier to preserve his own life; that the expense is an insurance by the owner of the safety of his mine. But I submit to all reasonable men, that when in our anxious search after the perfect lamp, we discard those lamps that for two generations have served us fairly well, we must not blindly rush into far greater and more constant danger than these from which we seek to escape; yet this is what there is likely to happen under cover of a permanently fixed shield, imperfect lamps may be given out and returned undetected, until some day there is an accident of which the cause will remain a mystery.

I now describe a few of the lamps. The Marsaut (see figs. 7 and 8), here we notice there is no ring below the glass, the glass is fixed by the oil-pot, this is the same in the Belgian-made Mueseler and in the Wolf lamp. This is in some respects a disadvantage, because it involves re-fixing the glass every time the lamp is cleaned—but in other respects it is a very great advantage, because it secures the glass in its position; whereas in those lamps where the glass is fixed

by a ring, the ring may be unscrewed by turning the glass, and thus the lamp may inadvertently be made unsafe.

Wolf Lamp. This can be re-lighted without opening. This relieves the collier from the temptation to open his lamp to re-light it, but it is a question, whether, if re-lighted in an explosive mixture, the flame might pass the gauze and cause an accident.

The Morgan Lamp (see figs. 9 and 10) is a safe lamp if the glass is locked and it gives a good light, like all lamps with the Mueseler chimney it is easily put out accidentally which is annoying. It has successfully resisted all trials up to 3200 feet per minute, but it can be exploded with very high velocities.

The Evan Evans Lamp (see fig. 11), is so made that it extinguishes itself when hot; the heat melts a soldered joint and then a spring is liberated which causes a cap to descend and close the air-holes.

The Protector Lamp (see fig. 6) cannot be opened without putting out the light, and the spirit they burn gives a good light with no trouble because the wick does not char; in using the spirit precautions must be taken and a specially arranged lamp-room made, because, if carelessly used it is sure to set fire to the lamp-room; as far as the lamp itself is concerned, when once it is locked the spirit is as safe to use as Colza oil and much cleaner.

The Clifford Lamp (see fig. 12) has several ingenious novelties. The double bonnet is so designed as to equalise the pressure of the air current on a lamp at the inlet and outlet so as to prevent it taking effect upon the light, in fact to make a perfect shield. In place of wire gauze there is a perforated plate made up of a copper and lead plate superposed so that if the lamp gets hot the lead will melt, the intention is to close up the air holes in the copper and put out the flame. The lower end of the chimney terminates in a bell of glass covering the flame; this diminishes the light, but by the means of this bell the lamp can be tilted without being upset. Mr. Clifford claims that his lamp will resist any velocity and that it has resisted a speed of 12000 feet or over two miles a minute. I saw it tested at a pressure of 1·4 inch of W. G. and it got red-hot but extinguished

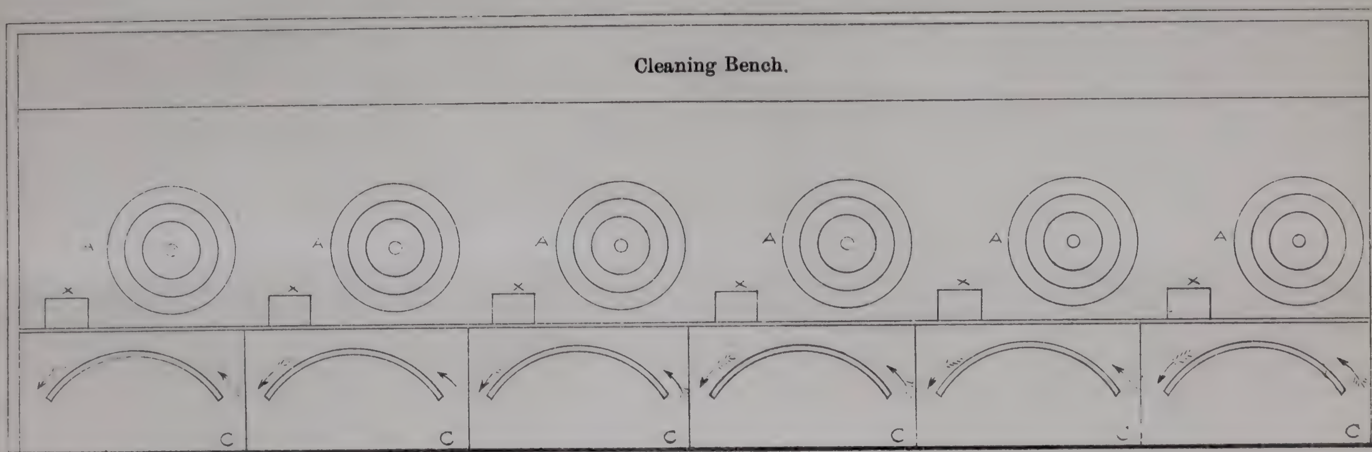


Fig. 14. Plan of a Lamp Room. Scale 12 feet to 1 inch.

A A A. Revolving Tables on which Lamps are placed ready to be given out.
C C C. Workman's Entrances.
× × ×. Small Tables on which the Lamps are put together and handed to the men.

itself in five minutes; under the same pressure the Morgan Lamp exploded in two minutes thirty-eight seconds.

Fleuss. This lamp is only for exploring mines full of gas. It is enclosed in a glass case, it burns spirit, and oxygen is supplied under pressure. The products of combustion escape through water. Unless it is broken it is quite safe.

The Mackinless Lamp has perforated brass plates instead of gauze, and has a Mueseler chimney.

In conclusion, let me sum up the results of our enquires:—

The lamp of the future will be one of the following:—

(1.) Electric Secondary Battery (Swan's).

(2.) ,, Primary ,,

(3.) Bonnetted Three Gauze (Marsaut).

(4.) ,, ,, ,, (Mueseler).

(5.) Inorgan Three Gauge (Mueseler).

(6.) Clifford, if it stands official tests as well as Mr. Clifford claims for it.

(7.) I understand the Mackinless lamp has not been exploded.

These lamps give light, which is what we want, and they are, so far as testing can prove them, safe (except the last, which is new, and for which I only give the inventor's authority).

All lamp cabins must be on the surface, and have enough delivering windows for the delivery of lamps to the men at a rate not exceeding 120 lamps per hour at each window, so that each man may see his lamp put together. The diagram shows a sketch plan of such a cabin. (See fig. 14.)

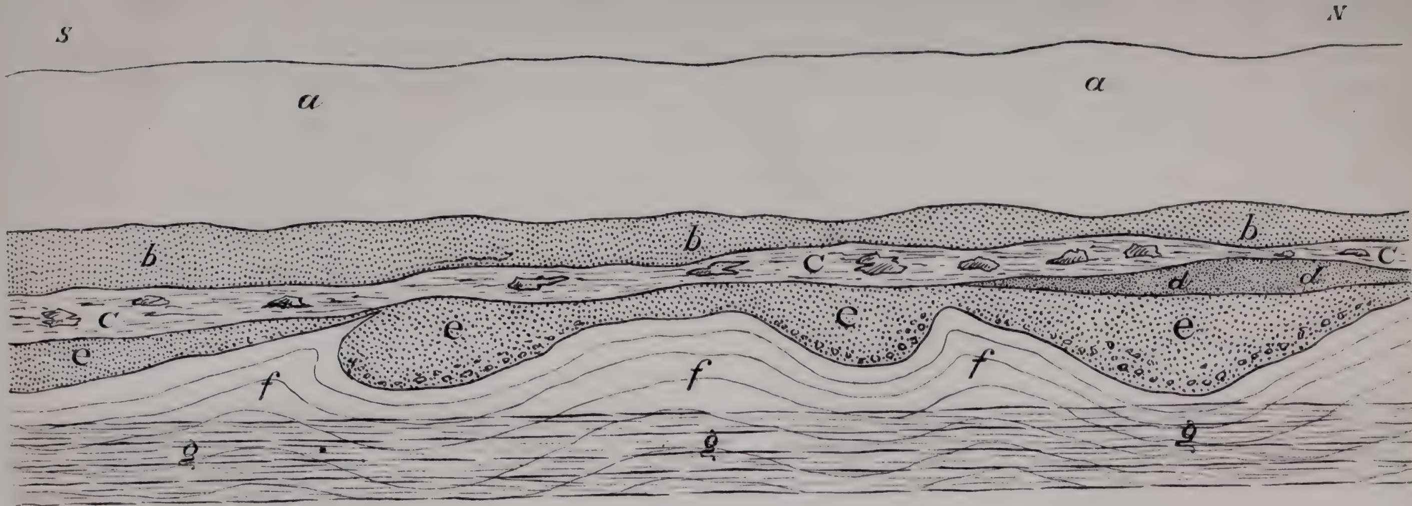
Without some such careful arrangement of lamp rooms the new lamps will prove worse than the old, but with due care they will prove much better.

I have said enough. however, to show how very carefully changes must be made, to prove how blind all legislation is likely to be. Lamps will be improved, but not by law. In these days of invention a law on mechanical questions is always antiquated by the time it is passed, and it hampers and discourages invention.

ON THE EXPLORATION OF THE RAYGILL FISSURE IN LOTHERSDALE, YORKSHIRE. BY JAMES W. DAVIS, F.G.S.

The Raygill Fissure, in the mountain limestone in Lothersdale, about five miles south-east of Skipton, was investigated to some extent by a Committee of the Society, and a report was presented by the Committee, and printed in the Annual Report for 1883. The fissure descended in a slightly diagonal direction in the form of a pothole from the surface to a depth of about 120 feet, and of this depth the lower 90 feet has been dug out and thoroughly examined, resulting in the discovery of numerous bones of animals, particulars of which are recorded in the report referred to above. The specimens are deposited in the Museum of the Philosophical and Literary Society at Leeds. Towards the close of 1883 it was found that the fissure assumed a more or less horizontal direction, and the work of excavation was rendered very difficult and laborious by the position of a large mass of limestone in front of the fissure, constituting at that time the face of the quarry. This obstruction the proprietor of the quarry very kindly engaged to remove, and operations were suspended to enable this to be done.

Since 1883 the face of the limestone has been quarried and the obstructing mass of limestone removed, and during the present summer operations have been renewed on the fissure. Its course has been traced to a distance of 114 feet, with a gradual declination in a south-easterly direction. The present entrance to the fissure is 4 feet wide: it diminishes to 2 feet 6 inches, but at a distance of 60 feet expands and forms a lofty cave, thence forwards the diameter again diminishes. The termination of the fissure, so far as it has been explored, appears to receive a tributary extending almost vertically in a north-westerly direction. The general direction of the fissure tends towards the hill-side, forming the channel of a water course at present running at no great distance; and it is probable that it formerly opened into it, although no direct evidence at present exists of the exit. Borings have shown the bottom of the fissure to be filled in with clay,



a. Silt
b. Gravel
c. Stony clay
d. Sand
e. Gravel
f. Fine blue clay
g. Carboniferous shale

SECTION IN EXCAVATION, OLD MILL, BARNSLEY.

varying from 6 inches to several feet in thickness, with slight alternating layers of sand and gravel, and occasionally fragments of grit and limestone at the bottom. A few remains of mammals have been found near the entrance to the horizontal portion of the fissure similar to those already recorded.

A very large sum would be required to investigate the remaining length of the fissure, because the work will be increasingly laborious and the consequent expense proportionately heavy; and as there is no probability indicated in the work so far that the already large series of animal remains will be greatly, if at all, increased, it is not thought advisible to proceed with the work at present. Sometime during next year the proprietors intend to drive a cross cut to the Barytes vein, behind the boiler house, and it is expected that this cutting will open up the fissure; should this be the case, it will be interesting to note the direction and contents of the fissure at that place.

In conclusion, it is desirable to render thanks to Mr. Spencer, and latterly to his son, the proprietors of the Raygill Quarries, for their permission to carry on the work, and for the uniformly kind and courteous manner in which they have always placed themselves at the disposal of the Committee; and to Mr. J. Todd, the manager of the works, for the trustworthy and careful manner, combined with much skill, in which he has superintended the operations of the workmen employed.

ON THE DISCOVERY OF A STONE IMPLEMENT IN ALLUVIAL GRAVELS AT BARNSLEY. BY SAMUEL A. ADAMSON, ESQ., F.G.S.

Some good sections were revealed by the excavation of a gas-holder tank, at Old Mill, Barnsley, and were visited by the Council of the Leeds Geological Association, by the invitation and under the guidance of Mr. John Hutchinson, the Engineer to the Barnsley Gasworks. The section on the east side shows the following strata in descending order:—A, silt; B, gravel; C, stony clay; D, sand; E, gravel; F, fine blue clay; G, slightly weathered shale (middle coal measures). The section on

the west side shows the same sequence, with the exception of D (sand) which is wanting. The junction of F and E is somewhat peculiar, the blue clay rising up in some places in bosses, some of which curve over in pointed tongues in the overlying gravel. The base of the section is a bed of ordinary blue shale (soft bind) evidently having been subjected to denudation before being covered with the overlying strata. The shale increases in hardness along with its depth. The clay, F, is of a fine texture, and is unmixed with other material. The gravel, E, varies very much, being of a fine nature in the upper part, but in the hollows of the blue clay consisting of coarse boulders, the chief part of these being local sandstone and shale, a large number also being of ganister and coarse grits. There are also some of basaltic and felspathic rocks. The presence of the ganister of the lower coal measures, the grits of the millstone grit series, and more especially the far travelled trappean rocks is worthy of notice. Overlying the gravel, E, is another layer of clay, C, of a dark colour, with a number of angular blocks of sandstone scattered throughout; these have evidently been denuded from the escarpments of the Dearne Valley. The clay also contains lenticular patches of fine sand, shown at D on the east side of the section. Above this stony clay is another bed of gravel, B, ranging in thickness from one to six feet, containing patches of vegetable accumulations, including oak and other kinds of wood, hazel nuts in great quantities, leaves, &c. There was also found a fresh-water shell (bivalve), and the leg of a beetle of a very brilliant blue colour, in the deposit. Above the bed B comes the silt, 12 to 14 feet in thickness, which does not call for any special notice. In the gravel, B, was found a remarkable implement composed of mica schist, smoothed, and having at the sides peculiar groovings, without doubt the work of human hands. In one of the grooves may be seen a growth of organic matter, deposited when it lay under water, thus attesting its antiquity. The implement is in all probability a whetstone; it has been worked, and was at one time longer. It has the appearance of having been used to sharpen some kind of instrument, probably an axe. The transverse markings could be made by the stone being rubbed along the edge of the axe to make it uniform, then the flat sides used to sharpen the edge.

A SKETCH OF THE PRE-HISTORIC REMAINS OF ROMBALDS MOOR.

BY JOHN HOLMES.

The history of any people, place, or event is only possible when civilisation has so far advanced mind, as to have arrived at signs and sounds significant of things, and of the arts rendering such signs perceptible upon a definite understanding. This marvellous advance of civilisation may be attained by pictorial representation (hieroghyphics) or by abreviated symbols of such pictorial figures, or of memorial-knots or signs upon any materials by a rude and barbarous people. They may be the most advanced phonetic systems of paper printing or of telegraphic communication, but without some such arrangement, history, as we ordinarily accept it, is unknown, and in fact impossible. The rude, the crude, and the most perfect mode of representation marks the condition of advance of the arts and the civilisation of any people, but all history tends to indicate and take us back to a period when neither civilisation nor arts were in a condition to make history. But long ere sounds were formulated into meanings or words, or signs into significant sounds, humanity existed, and men associated, lived, acted, and died. As there were men brave before Agememnon and wise before Ulysses, so there was society before history, with components doubtless relatively as characteristic as in the nineteenth century.

In order to live, men are constantly acting with the materials of nature, and whether this be registered by history or not, the remains of their actions exist long after them, and probably will long after any special recorded history. The remains of men's actions are, when understood, a most accurate record of their condition, and a most reliable evidence of both their individual life and social arrangements. The investigation of the remains of humanity before the art of recording, and its correlative influences and conclusions is properly called pre-history, and should be the foundation of history. The pre-historic condition of a people not only throws light upon the history, but without this it is impossible to understand the relations

and sequences fitting in the history, and hitherto students have only studied the conditions of humanity if History; but the advanced masters of philosophy now say that we are likely to profit more by a careful study of pre-historic man, than we can by that of man in historic times. The infancy and childhood, and what we call the barbarism of dawning civilisation are, if properly studied, most significant of what should be the right training for the future; and the importance of a right training of society is of equal importance to society as the training of an individual is to himself.

Affirming the study of the pre-historic to be important, we turn then with interest to those localities where pre-historic remains abound, and so we turn to the remains of Rombalds Moor, as not only exceptionately abundant, but as singularly significant of fact and phenomena in the conditions of pre-historic humanity. Pre-historic remains, as now studied, all over the world are classed less in relation to time and place than to circumstance and condition, seeing that we have to-day rude stone implements in use both north and south, exactly such as were commonly used in the most remote times, in England and elsewhere, when civilised. Broadly classed, the actions of humanity, and so of course their remains, relate first to the conditions of life; second, to the respect of death; and, third, to their regard of a future existence. Under these heads we have pre-historic remains of dwellings, inclosures, mounds for offence and defence, tools, pottery, and miscellaneous implements of war and peace. Under the second we have graves of all kinds; tumuli of earth. and cairns of stone; dolmens, menhirs, and stone circles, in which are found remains of personal ornaments, implements, and objects of memorial or of use in relation to the dead. We have interments of simple burial, of attempts to preserve (rare), and of cremation or burning, in which the ashes are left or they are enclosed in urns specially made and used for the purpose. Over the dead thus placed for honour or regard we have green mounds and remains as instanced. Under the third head, the relations of the future, the remains are much more open to question, but judging from the present, that barbarous peoples, i.e., those now living in the conditions of prehistoric ages and people, we take certain remains to be evidences of

the superstition or worship in the past. These are circles and pillars, and objects of stone, unworked or figured, naturally or artificially placed. To these may be added mounds of earth of considerable size, which though probably at first simple grass mounds, becoming famous, were increased and made sacred to religion, and then utilised as places for meetings, ceremonies, and for legal transactions. Objects and methods originally superstitious might be made available for other purposes, and so cannot well be classed under any specific definition.

This very brief and imperfect classification of objects left by people of and from the most remote antiquity, will not find actual illustration or evidences in any one place or locality. They may be found wherever men have existed, but, wherever found, they are the evidence of both the existence and the condition of the people living, and whatever be the diversity of circumstances they show certain traits of humanity common to the whole. We may thus infer that different objects indicating ideas or habits at one place will have a similar significance at another, however distant in place or time.

Rombalds Moor itself is an elevated track of wild moorland, which formerly must have been miles larger all ways. The district of our especial investigation is bounded by a line north up the Aire Valley from Calverley Station to Menstone, and so on to the Wharfe, say about 250 feet above sea-level, and by another line rising from the Wharfe to Addingham, 1000 feet; and from Addingham to the Aire near Keighley, falling to 300 feet. This moorland, bounded by the Wharfe north and by the Aire south, includes a span of between 6 to 7 miles east and west, and 4 to 5 miles north to south. The extreme height is 1,322 feet, rounding from river to river, rising highest about mid-way between north and south, at White Crag, and falling from Addingham 1000, to 300 feet west to east, at Calverley Station. The millstone grit rises in five or six terraces from the Wharfe to the top, which on the south side is much cultivated, having Silsden, Marton, Hawksworth, and Baildon, all manufacturing villages, at the lower parts. On the north, bleak and bare, the terraces are much more evident, and are only cultivated from the Wharfe for four or six hundred yards up the sides, leaving seven to nine hundred yards bare

rock, rough moraine-leavings on inclined beds, covered by bog, ling, bracken, or brushwood in patches, to the cultivated enclosures and the well grown trees common to the district valleys. So far as history records, the centres of Rombalds Moor were never in a different condition naturally, whereas it is evident that at a period relatively recent in geological times the condition of Rombalds Moor was very different to the present. At the very top of the moor, now all bleak. bare, and bog, it is evident the larger trees grew in forests of oak, elm, and birch. The two former were often taken out of the bogs at Lanshaw and elsewhere, in the memory of old people recently living, and the silver birch has been found to be numerous in the bog on the top of the moor.

The evidences of primitive man upon Rombalds Moor exist in its pre-historic graves, in its remains of barbarous life and action, and in its objects of superstition and primitive art.

About 1844, Mr. Edward Hailstone, F.S.A., and Mr. J. M. N. Colls made explorations by digging, and gave an exhaustive account of the results, which was published in the Archeologia, vol. xxxi., p. 229. This Mr. Wardell, in his early remains of Baildon Common, thus summarises: "The first excavation was made near the centre of a circle composed of earth and stones, measuring fifty feet in diameter, on the south-east side of Baildon Common. After removing successive layers of peat, earth, and calliard boulders, at a depth of two feet from the surface of the ground, there was found in connection with the remains of a fire, a rude urn of circular or bowl shape, twelve inches in diameter and about nine or ten inches in depth, ornamented in the upper part by incised lines crossing each other at right angles, lozenge-wise. It was in an upright position, and filled with calcined bones, ashes, and charcoal. The bones, some of which were quite perfect, were submitted to medical inspection, and pronounced to be those of a young person of from nine to thirteen years of age. The next examination was made in an earthwork of a peculiar character, situated on the north side of the road crossing the common, consisting of the remains of a circle composed of the same materials, and of the same dimensions as the last, but bound on the south and east sides by a well-defined entrenchment, the form of

which will readily be understood by a reference to the annexed woodcut. It is in the form of an angle or corner of a parallelogram, and measures eighty feet in length on the west, and thirty-six feet on the south side. It consists of a fosse, with an agger on each side. The breadth of the fosse from the top of each side agger is about twenty-seven feet, and the depth about three feet four inches. The length of the two outer ridges or aggers is two feet four inches, and the entire breadth of the interior edge to the exterior edge of the outer agger is forty-five feet. Within the circle, which appears to have been disturbed previously, were found ashes, burnt bones, and charcoal, together with a broken urn. At a distance from these remains, and at a depth of two feet from the surface, another broken urn was found, which when entire had been about seven inches in diameter and nine or ten in depth. It was in an inverted position, ornamented by zig-zag (chevron) lines, and contained similar remains to the last, among which was a flint arrow head, represented exactly by the annexed woodcut. Another examination appears to have been made by other visitors to the common, in a cairn almost reduced to the level of the ground, where after removing stones to about a foot in depth, there was found a small quantity of ashes, charcoal, and calcined bones, apparently those of a young female, amongst which were the remains of a small earthenware urn, reddened by the action of fire. This, judging by the fragments, had been about four inches in diameter at the top, and six or eight inches in depth, of the form represented in the woodcut." Mr. Wardell, in the above account, hopes that these interesting remains may be preserved from the demolition that all the neighbouring cairns have suffered under, by labourers removing the stones comprising them, for repairs to the roads. A visit paid in August, 1883, showed to the Bradford Antiquarian Society the fact that they had remained much as left by the explorers, or at least there certainly had been no systematic attempt to disturb or destroy them. It may be added that a similar urn to the last was discovered in a dish-like circle filled by the evidences of cremation at Hough Hill, on the other side of the Aire, near to Pudsey, about four miles distant, in December, 1879.

These positive and characteristic evidences of the dead are

worthy of considerable notice, not only because such remains are very rare in the district, but as shewing the similarity to many others all over the British Isles, of objects, conditions, and stages of art and associations. We have the positive fact of cremations, the remains being left in the fire, and in other cases collected and placed in hand-made urns, ornamented by incised chevron lines upon raised folds or over-lapings at the mouth. The pottery is very rude, sun-dried, and then open fire-burnt, as are so many of the native British urns, wherever that tribe or people lived and settled.* The flint arrow head is exceedingly interesting, and significant of all the facts that such arrow heads are well understood to involve and include. And though no similar urns or remains are known of, they may fairly be assumed to have really been deposited in other cairns and burial places on the moor. Two cairns, known as the Big and Little Skirts full of stones, and one, if not two circles of stones near to the grubbing stones and shooting tower, were in all probability burial places originally, surrounded by upright stones or pillars or covered over by smaller stones for protection, notice, or memorial. About a quarter of a mile north-west of the shooting tower the large Skirtful of stones measures eighty-six feet in diameter, and some six or seven feet high. It has a ring of larger stones set in the ground at the circumference, and from a hollow in the centre it appears to have been examined, without any record of results having been made.† To the north of this, the little Skirtful of stones appears, like the other, as though gathered by hand, and averaging fourteen to eighteen inches in diameter. Legend gives both their names from witches following a giant to pelt him, when after extra strides (from Almias Cliffe, four miles off) the strings of their skirts broke, and so the stones were dropped in heaps as we now see them, except much less, from being utilised for roading. Such legends assuredly carry their ages beyond the historic period, and originating when all knowledge of their real purpose had been lost in times still more remote. Other and world wide evidences justify the opinion that these are funeral relicts, and that the numerous mounds scattered from these cairns to Woofa Bank and Green Crag, are the

* See Greenwell's British Barrows, 1878.

† Since this was written a more careful examination has shewn decisive evidence of funeral remains.

earth graves of the people of less regard. We have no chambered or dolmen graves upon Rombalds Moor, nor, with a few exceptions, are there any single pillar stones which could fairly be identified with either grave or memorial. The exceptions are Cooper's Cross, on the west, near the old Roman track from Keighley to Ilkley, and the Lanshaw "lad and lass," uprights at each end of the Lanshaw Delves. One or two others are probably still remaining as boundary stones; there may have been more of both stone tumuli, circles, and pillars in the olden times, for over a thousand years we have the fact of clearances and utilisation of stones for any purpose, and that still going on.

But while lacking many of the pre-historic features common in other localities we have an abundance of pre-historic evidence of another character. Thus under the head of religion, or superstition, we may class those incised stones or slabs, known as the "cup and ring marked rocks." In this way for the time we will consider these singular remains of Rombalds Moor, even though we may come to give a much more utilitarian character to some of them.

Stone marking has been common all over the world, whenever men have sought to register objects or ideas that they wished to perpetuate: and people have observed stone markings as long as they have observed anything. We have had observations noted, in a casual way, of what is now called cup and ring incisions, from the time of Borlase, who published a very accurate description of them, as figured upon dolmen top-stones in Cornwall, 1769. Cup and ring marked rocks were noticed at old Berwick, Northumberland, 1825, and at Carnban, Scotland, 1830. Sir Gardner Wilkinson pointed out ring marks upon the Solkeld circle, Cumberland, 1835, but not until the Rev. Canon Greenwell of Durham, and Mr. George Tate of Alnwick, discovered simultaneously, a series in Cumberland in 1851-4, that any especial notice of them was taken. These being shewn at the Archæological Meeting at Newcastle, 1863, it was found that others had seen similar markings in other parts of England, Scotland, and Ireland; and then it was found that such markings had been seen in places all over the world. The cup and rings were first figured as such, significantly, in the London Illustrated News, March 19th,

1863. Borlase and others figured them only as curious marks of remote times. The oldest figuring on record of the cups and rings are upon a Mosaic pavement brought by Adrian from Athens, A.D. 270, but which would be in all probability contemporary with Alexander, B.C. 330, as the subject relates to transactions of his, in the Persian Conquests. Upon the rock regions of Ethiopia, as given in Montfaucon, the cup and ring marks are unmistakably figured. (See Shaw's Travels, London, 1757.) As perhaps among the last of such markings, and to show the range in extent, we have the cups and rings figured upon sacred stones (Lingams) in the Island of Figi. (See Figi and the Figians, by Williams and Rowe, two missionaries. London, 1858.) Such markings, so much alike as to appear by the same hand, and placed apparently for the like intention or object, have been found in North and South America, very extensively in India, very numerously upon the Dolmen of Moab,* (exactly like a number in Cornwall), they are numerous in Ireland, Sweden, and Denmark, and rare in Egypt and Africa. Indeed they are so extensively placed that we may say it only requires observation to find them everywhere. They are, however, neither uniform in order nor numbers. They are more numerous in Ireland and Scotland than in England, more in the North than the South of England, even under similar conditions of rocks and surroundings.

The cup and ring marked rocks upon Rombalds Moor, or rather the markings upon the millstone grit there, have doubtless been seen for ages, and were perhaps noted by Dr. Call years ago. In 1886, a gentleman named Terry, staying at Benrhydding, was standing at the head of the quarry below the Cow and Calf, and saw the men baring to extend the quarry, and as they took away the turf, towards the Cow rock, he observed the curious markings there, quite fresh and clean cut where they had been covered. Having heard of the cup and rings elsewhere, they took his attention, and he induced Dr. McLeod to refer to Mr. Myddleton, the Lord of the Manor, to allow these beds and rocks to be preserved. This the doctor did, and so we have them there for observation to-day, whereas, if unforbidden, they would

* See Lieut. Condor's Report, April No. of Palestine Exploration Society. London, 1883.

have been destroyed, as certainly many others have been. Upon this bed of rocks, glaciated, smoothed, and striated, we have curious markings, cut clean and deep where preserved by the covering of turf, and worn, so as to be scarcely observable, by frost and weather when exposed. By invitation of Dr. McLeod I saw them early in 1867-8, as did Mr. James Wardell and Mr. Forrest; who both named them in their essays of that year; the one in his "Walks on Rombalds Moor," and the other in his "Historical Notices of Ilkley, Rombalds Moor, and Baildon Common," 1869. Mr. Forrest, in his Walks, figures accurately from a rubbing, the Cow and Calf Quarry markings. But while there were vague conjectures and wonders raised, there was nothing decisively known of their bearing or significance, until I accompanied Canon Greenwell to see them, and a few others, early in April, 1870. Canon Greenwell at once said that they were genuine and interesting specimens of the typical cup and ring marked rocks, and so they took a place which has since been advancing in importance, as observed and investigated, among those curious and even mysterious subjects, the world-wide rock markings.

The first publication upon the significance of the Ilkley cup and ring marked rocks, was in an article furnished to the Leeds Mercury, April 20th, 1870. It may be added that later writers upon the Rombalds Moor rocks are the Telegraph correspondent, and the Revs. Brook Harford and Montacu Conway, 1876, 7 and 8, and that the last discoverers and investigators are J. Romily Allen, A.I.C.E., and C. W. Dymond, F.S.A., in the Archæological Journal, March, 1879, and June, 1880, and Fredk. W. Fison, Esq., in his able address to the Ilkley Scientific Club. The last very important discoveries are those of Lieut. Conder, Captain Warren and others of the Palestine Exploration Fund, in Moab, on the east side of the Jordan, North of the Dead Sea. There from Gerasa to Keferin, Raboth-Ammon, Heshbon, to Baol Meor and Dibon, hundreds of menhirs and dolmens are found centered about springs or holy places, some, if not many of these bearing exactly the same cup and ring marks that Borlase found upon the dolmen in Cornwall (1737), and so similar are they to some upon Rombald's Moor and elsewhere that Condor's description and conjectures upon the markings

given in the April and October numbers of Quarterly Statements, 1882, and again in the "Heth and Moab" of Lieut. Condor, October, 1883, might be taken as belonging to each and to all places, viz., to Cornwall, Rombalds Moor, and Moab. In fact, Condor and Borlase, in their word descriptions, may be transposed, without finding out the difference, except in the locality. These cup and ring markings being so widely apart, end so curiously similar, we are impelled to ask why they are so alike? and what they mean? In this, it is as usual, easier to say what they are not, than what they are. Firstly they are not natural figurings, but they are artificial markings. Nor, second (except in a few instances where the pre-historic clearly blends into the historic, in Ireland, France and Sweden), are they the representations of any natural objects? They may be symbols and representations of some thing to which we shall shortly refer. Third, that they are not historic anywhere, is clear, seeing that we have no history nor legend whatever as to what these curious incisions mean, or how, why or when, they were made. Fourth, another fact is of great importance, viz., that they are not Christian. Some are noticed in lands that never heard of Christianity, and while from the first century A.D., the Christian cross has been prominent wherever its doctrines have been preached; there is neither sign, symbol, or evidence that these rock markers ever had any knowledge whatever of it. These facts will place the cup and ring marked rocks of Ilkley in pre-Christian times assuredly, and this must be considered when weighing the opinions of those who, with Ferguson, would make them relatively modern. The artificial placing of menhirs and dolmens, with their markings, are contemporary, and that the placers of the one are the markers of the other, is an inference so conclusive to experts as never to have been doubted or objected to. Of many writers, Ferguson says of these remains, "they are of one people wherever placed, bear one impress, and tell one story of art and object." (Rude Stone Monuments, Introduction, p. 28). "One point there will be little difficulty in proving, which is, that the whole form one continuous group extending in an unbroken series from the earliest to the latest. There is no hiatus or break anywhere." Now, as Ferguson puts it, "they are either the work of men

so remote as to be beyond mortal ken, or they are the sepulchral monuments of a people who lived so nearly within the limits of historic times, that their story can easily be discovered," we may ask Mr. Ferguson, in his own words, to give us the story. Who were these people? the dolmen builders? and stone markers? Where did they come from? where and when did they go? His own map shews the distribution, and probable lines of migration, of the stone-markers and dolmen builders, from North Africa, through Judea, and to India, East; to Spain, France, Ireland, Wales and England, and Scotland, West; and Germany, Denmark, Sweden, and Russia, North. The numerical distribution is exceedingly unequal, as shown by the deepening of red spots, wherever they are found upon the map; not knowing of the recent discoveries in Moab, it is left blank upon the map, but in South and North Spain, in France all through, West Wales, and East Ireland, in Germany, East Denmark, and South Sweden, the dolmens are very thickly planted. In Italy, Greece, and Turkey, next to none, and in India but very few, apparently. A correction would now give many in India, many in Arabia, and very many in Moab, and the East of Jordan, North of the Dead Sea. Similar circles and dolmens, with markings, have been found in Peru, and in Australia. Mr. Ferguson's three conclusions are, "that they are generally sepulchral, or connected with the rites of the dead; second, they are not temples in any usual or appropriate sense of the term; and lastly, that they were generally erected by partially civilized races, after they had come into contact with the Romans, and most of them may be considered as belonging to the first ten centuries of the Christian Era." The first two we may pass, but, if Anti-Roman, they could not commence being erected before 500 A.D. We have then but 500 years, i.e. from 500 to 1000 A.D. in which the erection of thousands of thousands of dolmens, including elaborate works such as Stonehenge, Karnack in Britany, &c., and from India, to Ireland, Spain to Russia, Sweden, Denmark, the Isle of Man, and Wales, to Phonecia, and Moab to Peru and Fiji, and to Australia, all to be erected! how they were placed, by a people nobody knows of, in a period when we have history written everywhere without a record, we leave Mr. Ferguson to reconcile and to account for. Take the

case of Rombalds Moor, (which is one of the most favourable to Mr. Ferguson) to wit. Suppose the Roman Olicana was destroyed in 500 A.D., and that all the following British and Scandinavian settlements and influence were wholly uprooted by the depopulation of Yorkshire, by William, 1068-9. What follows? We had certainly a Saxon (Scandinavian) Church at Ilkley before this depopulation. Witness the, at least, four crosses, three still in the churchyard. But how with these (and the Romans were christianized after Constantine, if not before) could they have been a pagan people, so numerous and so long resident as to dig the graves on the common of Baildon, and erect stone circles, tumuli and the score of rude monuments upon the moor (then not of Rombald?) How could these pagans be contemporary and flourish in time parallel with the art of the Ilkley crosses, leaving neither legend nor record of any kind of their existence? Of all hypotheses of antiquity we submit Ferguson's to be the most incredible, and hence we accept his alternative and refer the graves, tumuli, stone circles and rude cup and ring marks of Ilkley to a barbarian pagan people, and to a very remote period to commence with, coming down possibly to the Roman invasion, and ceasing everywhere with the growth of power and the introduction of Christianity. The rude stone monuments of Peru, of the Pacific Island of Tonga, Victoria and other parts of Australasia are beyond our limit to account for.

Having very crudely and imperfectly glanced at what those markings are not, we may similarly glance at what they are. They may be defined as artificial cuttings and figures upon rocks or ancient stone monuments, always of a rustic period. The simplest are hollow, of from two to three inches in diameter to six or more, and from one inch to six or eight deep, proportionate to size. They are chiefly of the small size, and are marked in lines upon any part of the stone on the side, ridge, or top without any evident order. Secondly, we have these hollows in cups, often surrounded by a ring, whole or broken, or there may be two, three, and even as many as seven rings round a circular hollow. Generally the rings are fairly circular; but some are more or less oval, serpentine, or spiral, and even tending to the square. Thirdly, from one cup-and-ring—hence

the technical name—a streak or groove may pass away, or may run towards or join some other cup or circle, and so connect them. Sometimes a streak or groove appears to be the principal, which the other figures, *i.e.*, cups and rings appear to be attached, but generally the circles are the feature, and the connections secondary. Sometimes a rude circle or boundary of other shape appears to surround or inclose cups. The streak or connexion usually goes direct, but occasionally it varies and bends, much like a road or stream. These, which may be called the typical forms, are given by Sir Jas. Y. Simpson as such, along with others of complex order and form, which may be designed to represent some things of order or purpose. No one hypothesis appears to account for or include the whole of the peculiarities of the cup and ring or inscribed rocks. With considerable diffidence, but with a full conviction of the fact, I submit that a twofold aspect of a common feeling or intention can be traced, which may account for all and every figuring that I know of. The general principle or object arises in our common humanity tending to represent externally that which we feel to be of importance, or we deem to be necessary or advantageous.

In this way, the sun, moon, and external phenomena of nature may become symbols, and worshipped as the objects significant of production; and the organs of the natural functions may be figured as indicative of the passions, and of their good or evil held to be actual at the time. The phallus or Lingam, and the Yoni, or crescent moon, have everywhere been used as the male and female emblems, and as implying increase, production, and blessing. In the end, the very emblems became themselves symbolised into conventional, simple, or more complex forms. Thus the circle or hollow dot, or cup and rings, are figured as symbols of the sun, as the sun itself was the symbol of increase and production. Growing more complex, the serpent represents the sun for both good and evil, as the action of the sun indicated in effect. It is a most interesting study to follow the order of symbolism or connection, behind the sun and the serpent, for good and for evil; but in result, each and all were used and figured as co-related and often identical. That this form should be common and extend from India to Egypt and as far south as Fiji is remarkable,

but the evidences are clear in the similar form and significance. The forms or modes of phallic symbols vary in different countries, although the principles and meanings are identical. In the North, Thor's Hammer and the Fylfot were identical with the Tree and Serpent of India, and of the Bull and Cow or Isis and Horus of Egypt, and of Jumbo in Africa and Fiji. These symbols all typified the ideas of the powers of nature, and of the estimate in which these were held.

It is at this stage of human evolution and art that we attribute the rearing of pillars, and the erection, formation, and modification of "rude stone monuments" all over the world. Feelings in common will naturally generate ideas, and even symbols in common, under given conditions, without any communication or personal associations. We may thus understand that the high monolith of Rudstone, in North Yorkshire, and the Devil's Arrows of Boroughbridge may be erected for the same reason as those of Carnack, in Britany. So we can realise that the circles of Salkeld, near Penrith; of Arberlaw, in Derbyshire; and of Stonehenge, near Salisbury, with thousands of others widely separated all over the world, may originate in a common feeling which naturally exhibits itself in a similar way at times and places most remote. We can trace how a single stone may increase into a circle or vary to a Dolmen or Cromlech. Or we can realise how such memorials may be identified with sacred events, as Jacob's Pillar, or the Stone Ezel of i. Samuel xx. 19, or to the grave stones of this day.

Stone pillars, or other symbolic monuments, would naturally be figured by the symbols further expressive of their own import; and we may thus account for all the cups, rings, circles, ovals, spirals, and serpentine markings found upon pillar stones, of which the figuring upon the Calder Stones, near Liverpool, figures by Sir Jas. Y. Simpson, and the phallic stones in Vol. II. of "Fiji and the Fijians," p. 220, are characteristic examples.* Of their import Mr. J. B. Waring, in his able work on the "Origin and Progress of Symbol Worship," [London, 1874, p. 95] says "Through the unknown ages

* These circles are instanced as significant, but others equally so are found in Ireland, Brittany, Sweden, India, Moab, and Peru.

prior to 1000 B.C. to seven or eight hundred of our era we find no remains of idol worship of any kind, or of carved temples. But ample traces in the way of symbols may be collected of an undoubted nature worship, in which, necessarily, the sun and moon form the principal features. Nature worship in the primitive form, to the great Giver of Light, Heat, and Life, has ever been in the open air, although the places of meeting may at times have been marked by upright stones." To which we may add, as before, that the stones themselves would become marked by the symbols expressive of their use. Upon Rombalds Moor we have met many such pillar stone erections, but some of them exhibit unmistakeable symbols of this type of marking. Of the second class or type of incised stones upon rude monuments, Rombalds Moor is rich, indeed contains more perhaps than any other place within the same limits, say three miles E. and W. by one mile N. and S. On the first recognisers of these cup and ring stones in Northumberland, viz. Canon Greenwell and Mr. Geo. Tate, both at first sight thought that they could trace the idea of a ground plan of forts or dwellings, or a chart of a district with roads. Sir Gardener Wilkinson, Dr. Graves and others held the same idea, and the former states that such markings were made upon the sand by the Arabs in times of danger to guide the forces in their routes. This plan or chart idea was for a time given up, but upon the Cow and Calf rocks Mr. Wardell says, 1869: "I can form no idea of their import, but they bear a strong resemblance to lines of earthworks and mounds of the earliest periods," and that "such markings in Northumberland and other northern counties are of frequent occurrence," p. 33. In the April number of Chambers' Journal, 1883, under the usual monthly glance at the arts or discoveries of the month, a paragraph states that these incised stones are very numerous and well known in Switzerland, and that in one canton Professor Rudriger has found so many that by placing them in connection he has found the whole to be a chart of the pre-historic condition of that canton, as to roads, stations, settlements, etc., of times very remote and prior to all history. In order to trace this remarkable feature further, I have applied to the Messrs. Chambers, but failed to

obtain any further information. Still this hypothesis accords so much to features common and striking, as I believe to be the most feasible yet started of the complex styles of figuring. At present it is but hypothesis, but bears probabilities such as, 1st, being like what charts or ground plans of rude works would be worked upon stones with such tools as these evidently have been ; 2nd, these curious or chart-like markings are chiefly found upon stones placed horizontally, or so inclined or placed as to be well seen, if not to court observation. All those at Ilkley show signs of being surrounded by a wall or large stones, as though to note or protect them. It is true that some have been found covered over, as at New Grange, and one at Craigie Hill [Sir J. Y. Simpson, p. xv.] formed the covering stone, with the circled face down. But these were clearly incised stones, re-placed or re-used, and were not in original situ, or were, in fact, carved for ornament or memorial. So we have these singular chart figurings upon the tops of huge dolmens in Cornwall, [Borlase, p. 174] and exactly similar markings upon the dolmens in Moab [See illustration and description of dolmens at Hesbon, Heth, and Moab, 1883, pp. 190-293, and in April and October Quarterly Reports of Palestine Society, 1882]. In Claperton and Denham's explorations in Central Africa a chart is given of King Bolino's domains, 5 to 15 lat. and 10 long., which, if placed by the side of stone on plate 5, and of Long Meg, p. 7, by Sir Jas. Y. Simpson, it will be seen that they are very similar in form and apparently identical in intention. Or place the chart of Thorsby's Course of the River Aire, 1715, with the district map of the Ilkley Guide, 1882, or any illustrated railway chart of any advertising railway route, and place them upon stones, and they will be found to be as much alike as possible. Were we to figure on first, second, and third class towns or stations by the actual number of circles round a dot or cup, we should get the actual figurings as upon our Ilkley stones, at the Panorama rocks ; and taking into account that ancient forts had from one to several circles, and that ancient Babylonian towns had from three to seven walls—Ecbatania to wit—and that towers had seven stages, and chart these upon rocks we shall have the reality of the stone puzzles plain

from bygone ages. For similarity to particular figures upon various stones, apparently exceptional, just take the general plate of British Barrows near Stonehenge, given p. 543 in Fosbrooke's Antiquities, 1843; and the similar plate of forts, earthworks, tumuli, circles, and camps, p. 557, and outline them upon stone, when every feature of the figuring given by Sir James Y. Simpson in his work may be seen, only often plainer for comparison upon paper.

This stone marking would be the way they would do them, and they could do no other, or at least in no better way. That in other times, with a country so sparce of inhabitants and difficult to track through, there would be a need of guide posts is evident, and there could be no plainer or simpler way of direction at the time, than to figure places according to these peculiarities and relations to each other in roads and ways. The subject—cup, ring, oval, or serpentine forms—say of symbol worship, or supersition, being inscribed upon stones, serving its purpose, would be naturally followed by similar incisions to indicate other purposes than such worship, and hence stone marking would become common for all purposes for which it could be used. But where the purposes varied the signs would be local. We thus find that the simplest form of nature worship, is the most extensive, in fact everywhere where men have felt the influence of nature and the desire to worship. But whether the advanced and more complex figurings be charts, ground plans or not, they are much more circumscribed in extent and much more confined to special localities.

Upon Rombalds Moor we have two specialties, the ladder or step-like forms, leading up to cups or rings, and the fylfot form upon the Addingham side ridges. Upon the hypothesis that the stone marking upon Panorama rocks are the charts of a district, and the representation of things, I should for illustration refer to the arched circular mounds of Algeria, pp. 398-9, 400-1-2 of Ferguson's R. S. Monuments ; and to those in India, pp. 490-1 of the same work. The New Zealand bure, or temple, could not be figured better upon stone than the two, three, or four ringed cups, with the well marked steps up to them, seven in number, upon twelve of the romantic rocks of

Ilkley. Of these bures we are informed, p. 221, Fiji and the Fijians, that nearly every town has one bure or more, many of which are well built, no pains being spared upon their erection or finish, which is generally placed upon a raised foundation, thrown up to the height of from three to twenty feet, in steps or rises, with dry rubble work of stone. The ascent is by a thick plank, having its upper face cut into notched steps. See cut p. 222, Fiji and Fijians, London, 1858. As proof, and positive as such proof can be made of two propositions, we cannot do better than place the cuts figured at pp. 220 and 222, along with the letterpress explanations.

"Rude consecrated stones are to be seen near Vuna, where offerings of food are sometimes made; another stands on a reef near Nalow, to which the natives came; and one near Thokova, Ne Titi, Levu, named Lovekaveka, is regarded as the abode of a goddess for whom food is prepared." This, as seen in the engraving, is like a round blank mile stone, slightly inclined, and having a liku tied round the middle. The shrine of O. Resoun is a large stone; he has also two large stones for wives." "Nearly every town has one or more bures, &c. Years ago I tried, without success, to obtain specific information upon these stones. Missionaries would do well, both for their own work and the extension of scientific ethnography, to ascertain and register carefully what the living natives think these things to be, as well as to obtain all possible knowledge of what they have been thought of and held. As it is, we cannot but see that they are phallic, and connected with phallic rites. We see that one stone has three well defined cup and ring figurings upon it, associated with their special rites and objects, and so far bears out our surmise of that form of "cup and ring marking." The cut of the bure or temple in Fiji gives the step-like figuring we see so clearly marked in the Panorama stones instanced on Rombalds Moor.

It is at present, perhaps, too much to expect that we may now account for or explain all that is peculiar in the rock markings, but it is only fair to the subject to explain all possible. Lastly, we will consider the two fylfot marked rocks of Ilkley, of which only one other illustration is known. The fylfot, or crux grammata, form is

that of a true cross, with a streak from the top to the angle of each arm, bending to the right of each arm from the centre, making, so far, the whole of a square. Except the circle and the angle this is, perhaps, the most widely distributed figure in existence, and as figured at Ilkley and Tossine, on the Swedish coast, it combines both circle and angle, and forms the line of beauty crosswise. Whatever may have been its original import, we can trace it perhaps first to India, where it remains as a survival figured upon the footprints of Buddha. [See Ferguson, Schlieman, and exhaustively in Wareing]. The word itself is old Norse, fiol; Ango Saxon, fela; German, veld; English, full, or many; and foot means many footed, or, perhaps, firm, stable, or abiding. Repetitions of the form are most numerous in Scandinavia. It is found upon very ancient British pottery. Schlieman finds it the most numerous figure upon the oldest whirl stones and pottery markings. It is common in Tartary, Thibet, Etrurea, in Greek, Roman and early Christian art. It is assuredly pre-Christian, but brought into Christian monuments from the third to the twelfth centuries, and has come down as a brassfounder's bell mark into the 17th century. [See Llewellyn Jewitt, Reliquary, 1881.] The fylfot is a prominent mark upon gold weights, brought from Coomassie, 1873, where it is evidently a survival along with other archaic figurings still in use. It ceased to be used upon Christian crosses with the decline of the Scandinavian runic figurings; but it has latterly been revived, without any other significance than an easy and effective form in mosaic, stone, or parquetry wood work. The fylfot figure usually stands along with others, as either significant of something or as an ornament along with other carvings; but at Ilkley, in two cases, and at Tossine in one, the figures exactly similar stand alone, or with the least possible connection with others. It does not look like a Christian symbol in any of these instances, being much more complex, difficult to construct, and is besides in each case connected with cup markings in the figure, so that a Christian cross can scarcely be meant. At Ilkley the outcurved line is say three-quarters of an inch in breadth, and three-quarters deep, the cups being about an inch and half in diameter and

depth. Stephens says that in Scandinavia this figure means Thor's hammer, or power; Cox, in Aryan mythology, recognises the male and female symbols, in which idea Inman agrees. In China it is worn as a charm, and one Italian antiquary says "it is an emblem of Libitina, or Persephone, the awful Queen of the Shades." Others say it signifies fire, water, and the union (?) of the two, etc. [See Wareing, pp. 10-40.] The fact is, while doubtless it had a meaning wherever first used, it has now lost all meaning to us. But there it stands at Ilkley, by whom brought, or with what intention, is alike a puzzle and a mystery. The conclusion that certain of these mysterious rock markings are the emblems of ancient superstition—and the symbols of nature or sun worship, appears to be as well ascertained as the relations of the subject and the conditions admit of. No other solution is equally tenable relating to that class of cups and rings, which, as before indicated, are frequently found upon upright or pillar stones. Upon those more complex or chart-like figurings the conclusions are not so definite nor so generally accepted. But believing that it has the best both internal and external evidence of probability, we are justified in accepting it for the time being, and until a more extended observation, if not positive investigation by pick and shovel, shall demonstrate the fact or disprove the hypothesis. The position of the stones bearing figures upon Rombalds Moor may be described negatively as having no fixed inclination. They lay at all angles of the compass, and in various degrees of inclination from horizontal to vertical. Only ten groups of figurings are known on the south side of the central ridge of the moor. Two stones, figured by Mr. Glossop in the Bradford Antiquay, Sept., 1882, are near to the Baildon Moor grave mounds, described on a previous page; and two or three others are upon Bracken Hill Green, at the top of Shipley Glen. They are evidently of the chart type. All else that I know are upon the north face of Rombalds Moor, at elevations of from seven to eight hundred feet above the sea level. They will extend from Addingham to Menstone, near four miles, in a direct line; and though a few are or have been covered, and one was evidently not in situation, the figures may be generally described as being cut upon good sized stones in important positions.

Indeed most of them have evidence of other stones being placed in circles round them. One, near Backstone Beck, characteristic but not very prominent stone, has a wall distinctly traceable all round it, at a distance of many feet from the cup and centre stones. There is generally a good look out from the top of the principal stones. Mr. Romily Allen numbers twenty-five only, while Mr. Fison says there are at least forty that he has seen. The most eastward are in a line from Woofa Bank to the "Skirts" tumuli; and those most western are the sepulchre stones upon Addingham Moor.

Taking them from east to west, the following may be given as a rough sketch or description of the principle of the cup and ring and chart figurings, modified from the papers of Messrs. Allan, Fison, and others. "Near to the pancake ridges there is a large ark-like block of sandstone, standing detached. It measures east to west 16 feet, by 8 feet 6 inches broad, and 5 feet 6 inches in height. The top is ridged houselike north and south, and is full of carvings upon each side. There are at least between forty and fifty cup hollows, and at least nine are surrounded by single rings or circles, having no connecting grooves." Castings of the top are in the Leeds Philosophical Museum. This is one of the stones shewing evidence of having been surrounded by other independent blocks; of which it is the principal or centre.

About a quarter-of-a-mile below this stone, north-west, we have a high mass of rock, called the Cow, from which a large block has fallen called the Calf. At the foot of the Cow the surface of the stone is relatively smooth, and the hill falling abruptly leaves these as cliff, the beds of which were being quarried for building purposes to the west. Up to 1886 the turf had grown from the moor to the edge of the cliff ridges, and this being bared to extend the quarry, a visitor at Benrhydding, as before said, saw markings upon the top of the bed as though fresh cut. The surface of the stone is glacially smoothed, running south to north. Mr. Allen gives a cut, in part i., vol. 35, of the Journal of the British Archæological Association, in which he says: "that the design cut upon the smooth surface consists of twenty-five cups of various sizes, from one to six inches in diameter.

Seven of the cups are surrounded by incomplete rings, many of them connected by an irregular arrangement of grooves. The plan and execution are so rude as to suggest the idea of these being in an incomplete state. The sides of the grooves are not smooth, and would seem to have been produced by a process of vertical punching, rather than by the means of a tool held sideway." This is the largest continuous sculpture upon the moor, and runs some 20 feet from the west, which was covered up, towards the east; bare, exposed, and walked upon, from deep and clean cuttings, to being weathered and worn until scarcely perceptible. This will account for the imperfection suggested by Mr. Allan, while the general bearing of the design suggested to both Messrs. Wardell and Forrest the idea of a ground-plan of forts, earth-works, and huts. That this idea is justified see figs. i., ii., and iii., in plate 4 of Wareing's Rude Monuments, 1870; and the ground-plans of old British villages on the Cheviot Hills and in Cornwall (figs. i., ii., iii., and iv., plate 12). It will be observed that what may be called the entrances open nearly all one way in the plans, and so they do in the Cow and Calf figurings, supposing the chart idea to be assumed. It was the uncovering of this rock that led to all further investigation, and when at first noticed there was evidence of a sort of rock wall or line towards the moor, as though for protection. This stone may assuredly be classed as chart-like. About midway betwixt the two stones now instanced there was up to 1871 a loose stone which had evidently been removed. It lay promiscuously among others, but it bore finer and deeper cut figures than any other upon the moor. Before noticed it had been halved by a mason, but a cast (in the Leeds Museum) shews the remaining cups and rings, cut as described. There were no grooves, and this stone might be fairly classed as one symbolic of the sun or nature-worship. In 1873 we regret to say that this, with many others, was cut up, and improved away for wall-stones, as many other similar figured ones have been. Higher up to the south, in a line with the Bakestone Beck, there is a stone with a number of cups upon it much weathered, only one or two shewing signs of rings. This is the one surrounded by a wall, which runs east and west down to

the beck, and at one part of the wall there is the appearance of a hut building (?).

Mr. Allan says that on a ridge of ground betwixt the two streams feeding the old baths, S.W., there is an isolated block of stone, 6 ft. by 6 ft. broad and 2 ft. high, on which are carved 16 cups, 6 of which are surrounded by rings. In the centre of them are two grooves which cut at right angles. Height 700 feet above sea level. Near to Grainings Head, some 1200 feet high, Mr. Allan notices a stone of great interest. It is a block of native grit 12 feet long by 7½ feet wide and 4 feet in height. The longest side faces S.E. and slopes at an angle of 40 degrees to the horizon, and upon it are nearly 50 cups, 16 of which are surrounded by single rings and 3 with double rings and radial grooves. At the other side or end near to the top is a curiously formed pattern of double grooves somewhat resembling the Swartica emblem discovered by Dr. Schlieman. At the highest part of the stone there is a rock basin 9 inches wide and 8 deep. On the vertical end of the stone are cut four cups, three of which have rings. This, says Mr. Allen, is one of the few instances of the cup and ring marks being cut on a vertical surface. Upon this we may say that such figures (the simplest) are very common upon vertical pillars. See Long Meg, at Salkeld, the Calder-Stones near Liverpool; in the tumuli of New Grange, and Douth, Ireland; in caves of Morbihan, Normandy; upon the rocks in Ethiopia, in the palerstini mosaic, Italy; and upon the phallic stones in Fiji. A careful rubbing of this so called Swartica figure gives the size to be 21 inches by 18. Rising from the village of Ilkley S.W. we pass by a villa erected by Mr. Joseph Lund, whose southern boundary wall crosses a large block, smooth topped, sloping N., having upon it, much worn down, a series of cups and rings, and one or two connecting grooves. Near to this stone Mr. Lund turned up with his spade a beautifully cut "thumb flake," 1¼ inches in diameter. It is in perfect preservation in the Leeds public collection. Betwixt this and the Panorama rocks there are several incised stones which we pass as having no special feature, except being of the chart types and horizontal in position. Rising the hill S.W., about a mile from Ilkley, we come to the Panorama rocks, upon the top of which there are a

series of slabs and rock-cut stones, which, Mr. Fison says, are the most beautiful of any yet discovered. Mr. Fison further notices that the arrangement of the surrounding stones, one of which may be a rocking stone, suggests the idea of an ancient enclosure; and he states that there he found two or three flint flakes. Mr. Allan states that the Panorama rocks, 800 feet above the sea, command a very magnificent view over Wharfedale. "Here there appears to be a rude inclosure, formed by a loose wall of low stones, within which are three of the finest sculptured stones of Ilkley. They lay almost in a straight line E. and W., the second being about five feet from the first, and the third 100 feet further. The first stone placed horizontally near the present level, is well preserved, being covered by the turf until recently. It measures 10 feet by 7. The sculptures consist of 35 cups, 18 of which are surrounded by concentric rings, varying from one to five (query six) in number. The most remarkable feature in the design is the very curious ladder-like arrangement of lines by which certain of the rings are intersected and joined together. I do not think that this peculiar type of carving occurs anywhere else besides Ilkley." Place these beside the Bure figured upon page 222 of "Fiji and the Fijians" and the significance of the figuring as a chart or plan will be seen at once. John S. Phene, Esq., F.G.S., F.R.G.S., &c., a distinguished traveller and expert in antiquarian researches, tumuli and mounds, on a visit in 1873, said at once, upon seeing the figuring of the circles and ladder shapes of the Panorama stones, that they were typical representatives or plans of many of the circled tumuli, and he had often seen in India steps intended, and, indeed essential, to reaching the sacred tops. Tumuli circles, such as figured from pages 398 to 431 in Ferguson's rude stone monuments of India, could only be figured on stone in the way these Ilkley sculptures are. This stone is one of the most curious and interesting, yet it bears no feasible hypothesis except that of a chart or ground plan, thus considered it is significant and singularly indicative and explanatory.

The second stone, 15 feet by 12, has a piece of the surface shelved off, measuring 6 feet by 4, the whole covered by cups and rings, many cups having no rings; several with one, and one with

two rings. As indicative of a barbarian village, or settlement, it is significant; otherwise we have no explanation to give. It has been exposed, and so is much weather worn. The third stone, 10 feet 9, by 7 to 8 feet, is slightly inclined to the north, has upon it twenty seven cups, fourteen of which have concentric rings, and four having two circles. It is a good deal worn, but shows in one or two instances, the grooves or ladder like steps so clearly marked upon the first or most eastward stone.

About a mile to the west of the Panorama rocks, on the very edge of the cliff forming the northern ridge of Addingham high moor, overlooking the Wharfe, is a large block of gritstone in situ, measuring 19 feet long, by 7 wide, and 4 feet 6 inches thick. At the West end are two rock basins, 1 foot 3 inches across, and at the other facing South, the very unusual figure of the fylfot, or swartica emblem, is clearly and deeply carved horizontally. This, Mr. Allan, (and I agree with him,) considers to be the most interesting of all the Ilkley sculptures. Except the similar, but less clearly cut figure upon the rock near Grainings head, (p 27) no other marking identical has been made known, except one carving found at Tossene, on the coast of Sweden, north of Gottenburg.

The significance and mystery of the swartica or fyltot we have before instanced, ranging from the foot of Buddha to Greek spindle whorls, and to the early Christian martyrs catacomb dresses, contemporary with similarly figured Roman Altars, both in England and Italy. But these three Ilkley carvings are explicable on a much less profound hypothesis. The fact is, the figure with its spots in cups constitutes a common school boy's puzzle play, showing how far rude men could build a wall which would exclude four poor men from the use of a well whose houses were nearer to it than was their own. However simple and ridiculous the latter solution may appear, it is equally a puzzle to account for figuring at Ilkley or Tossene as a puzzle, as to account for the fylfot been so widely figured in remote times as a sacred emblem, the facts are impossible to deny, and so we must for the present leave the puzzle. "The Addingham crag stone situated further west, is at the foot of the cliff; measures 9 feet 6 by 8 feet 6 inches broad, and stands detached about 4 feet in

height. Upon the top surface are cut twenty-three cups, twelve of which are surrounded by single concentric rings, which in two cases have connecting grooves. On the West side of the stone is a sort of pocket, which may be natural or artificial, and ten long grooves run across the stone in the direction of the grain." There are many others scattered upon the moor, and a careful investigation would doubtless develop others unknown. These stones are being constantly cut up. Three or four described as good ones, were cut up by the labourers in making the new road up to the panorama rocks, 1882. Another very large one below the Cow and Calf series, which must by description have been exceedingly fine, was cut up a few years ago. It is to be greatly regretted that from the neglect or supineness of the residents of Ilkley, no attempt is made to preserve objects of such superlative interest to both archæologist, student of humanity, and the ordinary visitor for health and recreation.

The subjects of the dead and memorials of worship and superstitions forming so small a part of modern life had, probably, in the semi-barbarian stages a much greater influence, and occupied more attention and time. It is clear by the evidences that men must have lived long upon Rombalds Moor to dig graves, make burial urns, erect mounds and stone circles, and carve upon the rocks the symbols we have so imperfectly described. Yet the evidences of their living and of how they lived, are singularly rare, or altogether wanting at Ilkley. We have no indisputable evidence of a British village upon the north side of the moor, where other works requiring time and labour are most evident. And upon the south side there are but two very probable settlements of huts evident, viz.: near the urn burials upon Baildon Moor, and from these another group going towards Shipley Glen.

Numerous hillocks of stone upon Green Crag, and upon other parts of the moor may have been huts, but examination fails to show it. Some of the hillocks excavated by Mr. Jon. Hainsworth, in the Lanshaw Delves, were in all probability huts for the lime-burners, yet in all these Mr. H. could find no actual proof of their being houses at all. But the life of hunters, or nomad cattle-tenters as the pre-historic people must have been, does not induce them to erect very substantial or permanent structures for living in.

In the recent discoveries of Dolmen and incised pillar stones in Moab, they find no corresponding "house property," while they do find rock caves, which were in all probability used as dwellings, and then utilised as tombs. But at Ilkley, with plenty of rocky crags, and lines of vertically exposed rocks, nooks and cracks, we find none that can be positively claimed as dwelling places. This negation of dwellings, where there must have been at one time a considerable population living, does show positively a very rude, crude, and in fact wretched condition of living. Even if the moor was then more covered by foliage, the trees found in the bogs of oak, firs, &c., prove that the winters would be at times very severe. And how they lived through them without coal and no means of clothing is a problem well worth the attention of our present prominent social reformers. It is certain, however, that they did live, and that they worked, and, therefore, they must have had dwellings and implements for work. But of these latter we have really very few remains. Flint flakes are not rare on the moor, they may be found on the bare places after wet windy weather, which tends to wash out and expose these characteristic objects. A few rude, and one or two fairly formed arrow heads have been found, and one well formed thumb-flint, as previously named; but of the knives, saws, drills, daggers and other objects of more perfect art in flint, we have as yet no instances upon Rombalds Moor; nor is there any instance found of hole-drilled large hammer heads, not uncommon in Yorkshire, both in flint and sandstone; nor is there one single evidence of bronze, or of any other metal being found upon Rombalds Moor, while bronze celts have been found at Keighley, and at Yeadon; where also some years ago there was a very valuable twisted Torque discovered, of fine gold. A very rare, but unmistakeable pickaxe, of Red Deer's horn, was dug up at 16 feet deep in cutting the sewers in Groove Road, Ilkley, about 1860. This implement, found by Mr. Hainsworth, is very significant. It is clearly before the time of iron, the use of which the Romans knew and made extensively at Ilkley; witness the various large slag-heaps still existing, or being just carted away for roads. The horn which was used as the pick was well worn and cracked by working, having grit-sand bedded

in the hollow surface. The handle was worn smooth where it had been held by the hands, as were those found by Canon Greenwell, at Grims Graves in Norfolk, all proving that this stag-horn pick had been used for digging or in all probability cultivating the soil. There is evidence of land culture upon the moor, especially in the little heaps of stones, the evidence of clearings both at Green Crag and at the Panorama Rocks. So the old names of Ryeley Wheatley, and Oatley are still suviving evidences that they had grain and pulse in ancient times, and several querns found upon and about the moor proves that they ground the grain, thus, or otherwise obtained. The pick was probably a horn of the red deer, then roving wild over their native hills, but the flint from which tools were made must have been brought a distance of fully sixty miles from the East-riding wolds. Most of the objects instanced are in the Leeds Public Museum, and Mr. Fison has a collection of flint-flakes, and a few more advanced objects obtained from the moor. Baking and roasting meat in earth ovens, heated by fire-stones, is relatively easy to savage men, while we have little evidence even of this, here in pre-historic times. At present we have no evidence of kiln-burnt pottery before the Roman occupation, so that boiling or even hot water must have been a rarity then among the natives. So we may here properly name that almost all the relics instanced must have been in use before the Roman civilisation. It is incredible to suppose it to be after the fifth century.

There are two other evidences of antiquity upon Rombalds Moor which may be called pre-historic, in the fact that there is neither history nor legend remaining indicative of either use or period. One is the long walled enclosure, one side of which is sheltered or bounded by the hollow and ridge of the Green Crag. This enclosure Mr. Allan describes as an irregular rectangle, 30 feet broad by 40 long, the two sides being prolonged for some 70 feet east to west. The walls scarcely rise a foot above the ground, and are composed of small stones. There is nothing to indicate the purpose for which this was used. Mr. Fison's remarks supplement the above thus :— "I am told by the old inhabitants that within their memory the walls of this enclosure were of considerable height, five feet or so, and that

large quantities of stones which comprised the walls were carted away. . . . . I am inclined to think from its shape that it has been really an enclosure for cattle, which were driven in at the open mouth west, and were secured in the inner inclosures." Mr. John James, the historian, of Bradford, held this to be an enclosure for cattle. He thought it was constructed by the Romans for the purpose of protection or shelter at nights in the feeding seasons upon the moor. As figured upon the 6-inch ordnance map, the enclosure looks very like those animal mound forms, such as we have figured in the Smithsonian transactions as frequent in Central America, North and South, and such as in serpent forms Mr. John S. Phene has proved to exist in various places in Scotland and the Hebrides. [See British Association Transactions, 1870-1.] There may be clearly traced the forms of heads to the east, body and tails to the west, the latter curving into an imperfect circle at the end, all being fitting for use as enclosures. In plate vii. Borlase figures a very similar enclosure upon Karnber Hill, having an irregular circle or head, a large body, and a continuation like a tail having a curve, just like the one on Rombalds Moor. This is composed of stones set upon edge, with smaller stones and earth filled in between. It appears to have contained cup and ring marked stones, and to have held tumuli or mounds, which might be a village of huts, of which the figured stones are a chart or plan. While this singular and still easily traceable object may be of a very remote period, it may also be of historic time and application. That caution in hypothesis as to use, time, and meaning of such relicts is necessary, we may instance in the other and last of our illustrations of the remains upon Rombalds Moor.

The Lanshaw Delves have always attracted notice, and have been characterised as a Roman camp or a British village, as the ideas of the investigator inclined. They were thus Roman to Whitaker and James, and British to Banks, Wardell, and Forrest. Mr. Forrest was very positive, as a few extracts will show: "What is called the camp is simply a British village, consisting sometimes of a double and sometimes a triple row of hut dwellings, upwards of a mile in length by about 40 yards in breadth, narrowing to the western ex-

tremity. All within this area is honeycombed with pits of a circular form, of from 10 to 20 feet, by about five or six feet in height at the centre. . . . . These pits we look upon as the foundations of our British ancestors, 'the blue shielded brigantes.' Over these holes thus delved into the soil they erected a covered roof of poles or branches of trees, which they covered with thatch or with sod so as to be weather proof, like the dwellings of the charcoal burners, only more substantial and permanent. At each end is one of a larger size, as though for halls of reception. That at the west end is upwards of 30 feet in diameter, and more than 10 in depth. Along the front of the main body of the village is a line of mounds of a different character ; they are twelve in number, and about 10 feet in diameter. Instead of being pits, as the others, they are hillocks, nearly all having an opening in the south-east, which opening discloses a mass of stones, some of which have been exposed to so fierce a fire as to be pulverised or vitrified so as to closely resemble ovens, which we conjecture these to have been, the common bakehouses of the community. There the game, whether wild boar or venison, was cooked, and the bread, if they had any, was baked." After a concise account of other such ancient and modern ovens and of the methods of cooking, Mr. Forrest concludes that "when the savoury morsel was done to the bone, then the door was opened, the meat withdrawn, and the feast at once begun," and for drink, why "water might be obtained from the springs above the swamp immediately in front." This really admirable description of certain present appearances, along with others, were duly placed before Canon Greenwell on his visit on that misty April day. The Canon listened as he looked, and then shrewdly said, to an appeal for his opinion, "I would try it with the pick ; that would clear away all doubts." Thinking that there was something in that, and that actual opening out would be as satisfactory as supposition, I engaged Mr. Jonathan Hainsworth to explore the Delves satisfactorily. In October, 1871, he did so, and on November, 13, 1871, the following was published as the result in the Ilkley "Guardian":—

Thus away went all theories of British village halls, of audience and venison feasts, in the certain evidences of these being lime-kilns,

and lime-kilns only. Mr. Fison, in his Ilkley address, admitting the certain fact of these delves being lime-kilns, asks, why did they burn lime in such an out-of-the-way spot in such quantities and in permanent use? What did they do with the lime so burnt, and where did they get the limestone, or fuel? Relative to the last, we may state that experts in geology have demonstrated that upon Rombalds Moor there runs a line of glacial drift limestone leavings, reaching from Lanshaw, north-west, to Hawksworth, south-east, which drift appears to have hit against the elevations in that line, and Lanshaw being highest, 1100 feet, would probably first catch the importation of Skipton limestone, and so on to the Whinhill, 800 feet, and Intake Delves, 700 feet. In that case there might have been a considerable quantity of lime drift at Lanshaw, to be utilised and burnt. The large turf bed at the south side of the delves has been well-known to yield large trees of old, and in times more remote would be full of fallen timber. There would thus be fuel. The particular covering of the front of the kilns and their facing south-east would catch the wind, which has always been blowing in that direction when I have been there, and so would make a natural "blast," enabling bog and wood to raise heat essential to fuse the limestone. Speaking of copper mines and smelting at Wady Maghara, Sinai, Lepsius says, (p. 102, Letters): "Hence it appears that this open spot was probably selected for melting the ore on account of the keen draught of wind which, as we were assured by the Arabs, is here almost incessantly blowing." We thus see that at Lanshaw, supposing a drift of limestone to be there, would have both fuel and a blast to work the burning. That they would use the lime thus laboriously made is pretty certain. We trace its use both by Romans, Saxon, and Normans in building, and as the lime would have to be brought down by animals in panniers, so when the drift failed they would be likely to take river boulders up and latterly coal, the cinders of which have been undoubtedly found in the bog and lime ashes of the Lanshaw kilns. Truck-ways, in one case near a dozen parallel, may be yet distinctly traced from the Wharfe to the delves, and the Wharfe yields limestone boulders yet for burning at pits now stationed near to the river. Formerly the facility for lime burning would be at the

top of the moor, and so they placed the kilns at Lanshaw, or Long-Riddings as best.

One might suppose that history would say something about the Lanshaw Delves, the enclosures for cattle, or the tracks and standing stone guide posts upon the moor. But it is silent, even upon the many lime-kilns of Lanshaw. Old men have heard older tell of big trees having been fetched from the bog there, when the kilns were wholly unknown. So the legend of the witches dropping their aprons full of stones forming the big and little Barrows will take us very far back in historic time, but of their real origin we have legend. The period is too far remote. So of the graves of Baildon, (the hill of Baal), the fuller circles of Rombalds Moor, and the cup and ring or chart incised rocks, we have neither whisper nor word, legend, story nor history. That they exist now is certain, and like the dry bones of Ezekiel's vision, it is certain that bone once knit to bone, and sinew to sinew, in the relations of ancient life. By the facts of savage life still existing we may dimly see in the grey dawn of times most remote that a tribe, probably similar to the Fins and Laps now, once lived upon the fringe of retreating glaciers on Rombalds Moor. We still find traces of the flint flakes, with which they scraped the bones of animals they had trapped on the hill or killed in the chase with their flint arrows, or found floating in the then extensive lochs. We can realise with a change of clime how they formed their huts, and then bred cattle. We can surmise of how they began to dream of the infinite, raise pillars to their gods, and dig graves for their dead. We can see how they interred their loved ones, placed the ashes of their dead in costly urns, and covered over their chiefs and heroes with earth or stones, and then circled them round to preserve their remains.

We can realise how they carved symbols upon their monuments, and figured what they thought or felt upon the rocks they held to be sacred. We can reasonably suppose how they grew into families, clans and tribes, associated with friends, and quarrelled with foes, and fought for wives, slaves, territory, or their gods. We can see how they might agree upon tribal boundaries, and construct common roads for transit or travel ; and then, as they thought, fixed them for

ever upon the indestructible rocks in elaborate and painfully cut lines, circles and figures for record. We can trace how they began to clear the soil, stones and weeds, and sow rye, oats and barley, and grinding grain by hand process ; then increasing their flocks, tending them on the hills, and sheltering them in folds and hollows ; they would gradually but slowly rise into domestic comforts. We can see how they dressed the hides of their cattle, and formed them for garments, and so evolved slowly and painfully from primitive barbarism to the semi-civilised condition that the Romans found them in. The valleys were then lakes or dangerous morasses, and the hill sides were covered-by dense forests. The tops of the hills held wood huts and villages, such as the New Zealanders still stockade. They became rich in cattle, had solid canoe boats or wicker corracles. Latterly they had framed wooden carts, and in some places chiefs had the use of chariots; they had acquired the use of metal tools of copper, bronze, gold and even iron. In some instances they traded with foreign countries, and copied the mediums of barter in metal and money. Foreign Missions had visited barbarian Britain, had advanced savage superstition to semi-civilised Druidism with divination, rude morals, and crude social organisation. It is common to stop at these patent inferences from these ascertained facts. But the intelligent antiquary may be permitted to look to the future as well as the past, and to conclude that as progress marks the past, it prefigures the future, or to "indefinite progress for the race —to state of being yet without a name."

SECRETARY'S REPORT.

The Society, during the past year, has made steady and continuous progress. The number of members is now 215, an increase of five on last year. Two members have compounded for their annual subscriptions, making a total of 33 life members. The Society has lost two members by death, and five have retired. There has been an addition of twelve new members. The two members whose deaths we have to regret are Sir Henry Edwards, Bart., C.B., &c., of Pye Nest, near Halifax, and Mr. W. Sykes Ward, of Denison Hall, Leeds. The latter was a very old member of the Society, and took great interest in its welfare. From the year 1854 or 1855 to 1870 he occupied the position of Honorary Secretary. He was a constant contributor to its proceedings, and read many papers at its meetings. He was a man of considerable ability and many accomplishments. He was by profession a solicitor, but his tastes led him in early life to scientific pursuits, and these he followed with rare ardour during his leisure time. He was a Fellow of the Chemical Society, and contributed to the transactions of that Society. During his earlier years he patented a system of telegraphy, and made inventions which he also patented in connection with a system of atmospheric railways. In his later years he devoted much time to photography, and achieved marked success as an amatuer in that art. He was an enthusiastic lover of music, and studied theories of sound with some success. In 1846 he contributed a paper to this Society, which was not published in its proceedings, "On Vibration Producing Sound." Mr. Ward was for many years a member of the Council, and for several, one of the Honorary Secretaries of the Leeds Philosophical and Literary Society. During the last three or four years he has led a life of retirement.

Three meetings, including the present one, have been held during the year. The first was at Barnsley, in April, and was presided over by Joseph Mitchell, Esq., C.E., F.G.S., who gave an address. Papers were also read by Dr. H. Clifton Sorby, F.R.S., Messrs. William Cash, F.G.S., G. R. Vine, William Horne, and H. B. Stocks.

The second meeting took the form of an excursion in Wensleydale

on the 12th and 13th of August. A meeting was held in the evening of the first day, at which Sir Charles Dodsworth presided. Between 30 and 35 members took part in the excursion. The Society is indebted to Mr. Wm. Horne, the local secretary for the district, for the admirable arrangements made for the success of the meeting.

The third meeting was held at Barnsley on November 17th, T. W. Embleton, Esq., in the chair. Papers were read by Messrs. J. R. Mortimer, Jno. Holmes, James W. Davis, Prof. Arnold Lupton, C.E., Rev. J. Magens Mello, M.A., Rev. J. Stanley Tute, B.A., and Richard Reynolds.

For the present year three photographs have been issued to the members of the Society, illustrating the contortions in the chalk at Flamborough Head. It is proposed to issue for next year a photograph, printed as before, by the Autotype Company, illustrating the fossil tree discovered at Clayton, near Bradford, and since purchased and removed to Owen's College, Manchester.

The Society is indebted to the following gentlemen who have represented the Society in the several towns or districts specified, as Honorary Local Secretaries:—

Barnsley	Thomas Lister, Victoria Crescent
Bradford	Thos. Tate, F.G.S., 4, Kingston Road, Leeds
Bridlington	Geo. W. Lamplugh, Bridlington Quay
Brighouse	Thomas Ormerod, Woodfield, Brighouse
Dewsbury	P. F. Lee, West Park Villas
Driffield	Rev. E. Maule Cole, M.A., Wetwang
Halifax	Geo. Patchett, Junr., Shaw Hill
Harrogate	R. Peach, Harrogate
Huddersfield	P. Sykes, 33, Estate Buildings
Leeds	S. A. Adamson, 52, Well Close Terrace
Leyburn and Wensleydale	Wm. Horne, Leyburn
Thirsk...	W. Gregson, Baldersby, nr. Thirsk
York	H. M. Platnauer, The Museum

The proceedings and memoirs of the learned Societies, whose names are appended, are forwarded to the Society; in exchange our proceedings are sent to them. The thanks of the Society are due and hereby tendered to those Societies for their respective contributions.

Essex Naturalists Field Club.
Norwich Geological Society.

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania, Van Diemans Land.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
Midland Naturalist, Birmingham.
Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria.
Societe Imperiale des Naturalistes, Moscow.
United States Geological Survey of the Territories, Washington.
Boston Society of Natural History, U. S. America.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis, U. S. America.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway, Christiana.
Sociètè-Geologique du Nord, Lille.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.
Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
Leeds Geological Association.
Patent Office Library, London.
Powis Land Naturalists' Club, Aberystwith.
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersburg.

It is desirable to draw attention to the circumstance that the subscriptions are due on the 1st January of each year, and to the great inconvenience occasioned by the non-payment of the subscriptions early in the year. The work of the Officers of the Society is thereby largely increased, and the efficiency and potential energy of the Society proportionately diminished.

The attention of the members of the Society is requested to the fact that Local Scientific Societies have been admitted as Corresponding Societies of the British Association and to the following statement thereon. In 1883 a committee was appointed by the British Association to draw up suggestions upon methods of more systematic observation and plans of operation for "Local Societies" which publish their proceedings. A list of such societies, numbering about 170, was prepared. The societies differ widely in character, ranging between those of high scientific character, whose affairs are managed by a regularly organised staff of officers, and whose operations include the original investigation of the various subjects, the results of which are regularly published in their proceedings; and small societies and field clubs, excellently situated for conducting local investigations, and often doing valuable work, of which, unfortunately, no accessible record is kept, and little is known. In some instances the small societies federate themselve together greatly to the benefit of all concerned. The societies so united are enabled to devise uniform and systematic investigations in a variety of subjects. It can hardly be doubted that such co-operation on a still more extended scale will result in important gains to science, and it is with this view that the committee sought to extend the system of federation and form an organized centre for local scientific societies in connection with the annual meeting of the British Association for the Advancement of Science. A number of proposals, which took the form of rules, were suggested for the consideration of the Council of the Association. In accordance with these any society is eligible to be placed on the list of corresponding societies of the British Association which undertakes local scientific investigations and publishes notices of the results of such investigations, especially if they are such as are carried on by committees of the Association. Application must be made before the 1st of June in each year, and the corresponding society when elected is required to transmit each year to the Secretary of the Association a copy of its proceedings during the last twelve months. A list of the papers published by such society during the year will be inserted in the Annual Report of the Association, providing they come under one or

other of the various sections of the Association. Each corresponding society has the right to nominate any one of its members, who is also a member of the Association, as its delegate to the annual meeting of the Association, who shall be for the time a member of the General Committee.

A conference of the delegates at one or more meetings is held at each annual meeting of the Association, and the secretaries of sections are instructed to transmit copies of any recommendation bearing upon matters in which the co-operation of the Corresponding Societies is desired, to the conference. The delegates are expected to make themselves familiar with the purport of the several recommendations as brought before them, in order that they may be able to bring them clearly and favourably before their respective societies. The conference may also discuss any propositions bearing on the promotion of more systematic observation and plans of operation, and greater uniformity in the mode of publishing results.

The Committee in framing these regulations believe that much mutual help may be the result; and whilst the Association hopes to derive benefit from the organized efforts of a large number of local workers, it is expected that the distinction accorded to societies through their connection with the Association will stimulate their members to greater and more useful exertions, and without in any way compromising their independence, will afford facility for the natural and healthy growth of a federation between remote societies which have no more direct bond of union than through the British Association. At the meeting of the British Association, held during the first week of September of this year at Birmingham, your Hon. Secretary attended as a Delegate from this society. At a meeting of the Delegates, on Monday, Sept. 2nd, various suggestions were made with the object of extending the usefulness of the local societies, and the representative of this society made a suggestion, which was afterwards adopted, viz.: that a record should be kept by local societies of all the evidence which from time to time may be discovered of the existence of pre-historic man. The localities and character of the objects should be noted, the former marked on a map kept for the purpose. The evidences to be included will comprise burial and

other mounds or tumuli, lake dwellings, caves which have been inhabited, entrenchments, and the several kinds of implements and ornaments of the Stone and Bronze age. The Committee of Recommendation adopted the suggestion, and appointed Sir John Lubbock, Dr. R. Munro, Mr. Pengelly, Prof. Boyd Dawkins, Dr. Meirhead, Dr. Jno. Evans, Dr. Hicks, and Mr. Jas. W. Davis a Committee for the purpose of making such investigations. Mr. Jas. W. Davis was appointed Secretary. Yorkshire has proved a rich field for the investigation of such subjects as are included in the programme of this committee; hitherto the record of many discoveries of interesting objects has been lost, or is hidden in the columns of some local newspaper. It is suggested that in future all such records should be carefully tabulated and preserved by the Committee of the British Association, and it is hoped that members of this society will communicate to its Honorary Secretary particulars of any discovery that they may be acquainted with. It is also desirable that particulars of interesting objects which have, previous to the present time, been found, and of which no permanent record has been made, should be furnished.

Amongst other subjects of investigation to which the society may be able to render assistance, are the "Sea Coast Erosion" Committee, appointed to enquire into the rate of erosion of the sea coast of England and Wales, and the influence of the artificial abstraction of shingle or other material in that action. Mr. Wm. Topley, 28, Jermyn Street, London, is the Secretary.

A Committee for the purpose of investigating the circulation of underground waters in the permeable formations of England, and the quality and quantity of the water supplied to various towns and districts from these formations. Mr. C. E. de Rance, 28, Jermyn Street, London, is the Secretary.

And the Committee to record the position, height above the sea level, lithological character and size and origin of the erratic blocks of England, Wales, and Ireland. Rev. H. W. Crosskey, LL.D., 117, Gough Road, Birmingham, is the Secretary.

Committee to report on the Provincial Museums of the United Kingdom. Mr. F. S. Mott. Leicester, Secretary.

Statement of Receipts and Expenditure of Yorkshire Geological and Polytechnic Society, 1885-6.

Receipts.	£	s.	d.	Paid.	£	s.	d.
To Advertising and Printing	75	17	0	By Balance brought forward, 24th Oct., 1885 ...	82	3	9
,, Sundries, Postal Expenses, &c.	8	17	3	,, Subscriptions, &c.	99	10	2
,, Engraving and Photographing	23	15	6	,, Bank Interest	0	17	0
,, Cash in Treasurer's hands	4	7	3				
,, Balance at Bank	69	13	11				
	£182	10	11		£182	10	11

CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance at Bank	233	8	7	By Balance brought forward, Oct. 24, 1885 ...	217	12	4
				,, C. W. Bartholomew, Esq.	6	6	0
				,, S. W. Duncan, Esq.	6	6	0
				,, Bank Interest	3	4	3
	£233	8	7		£233	8	7

RAYGILL FISSURE ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance at Bank	46	19	8	By Balance brought forward, Oct. 24, 1885 ...	46	7	2
				,, Bank Interest	0	12	6
	£46	19	8		£46	19	8

Audited and found correct, GEO. PATCHETT, Jun.

MINUTES.

Meeting of the Council at the Museum, Leeds, on March 10th, 1886.

Present, R, Peach, Esq., in the chair; Messrs. Reynolds, Tate, Platnauer, Carter, and Davis.

The minutes of last meeting were read and confirmed.

Proposed by the Chairman, seconded by Mr. Platnauer, and carried, that the following accounts be paid:—

	£	s.	d.
Autotype Co. - - - - -	17	10	6
G. Willis (Photographer) - - -	6	5	0
	£23	15	6

The Hon. Secretary stated that much delay in the issue of the proceedings had been caused by the negligence and delay of the printers, and it was decided, on the motion of Mr. Reynolds, seconded by Mr. Platnauer, that tenders for printing the annual proceedings be invited from Messrs. Goodall and Suddick and M'Corquodale, of Leeds; and Whitley and Booth, of Halifax.

It was decided that Lord Halifax be invited to preside at the next meeting, on the 8th or 15th April, and that if he accept the invitation, the meeting be held at Doncaster. If his lordship cannot be present the meeting to be held at Barnsley on the first or second Wednesday in April.

Meeting of the Council in the Council Room, Town Hall, Barnsley, on Wednesday, April 21st, 1886.

Present, Rich. Carter, Esq., in the chair; Messrs. Peach, Ray Eddy, Cheetham, Lister, Dr. Sorby, and the Hon. Secretary.

Minutes read and confirmed.

Estimates for printing the proceedings were read from Messrs. Goodall and Suddick, Messrs. McCorquodale, and Messrs, Whitley and Booth. Mr. Ray Eddy proposed, and Mr. Cheetham seconded, that the estimate of Messrs. Whitley and Booth be accepted, and that the type be same as previously issued by Messrs. Megson and Sons. Carried.

Resolved to recommend that the next meeting be held at Leyburn, and that an excursion in Wensleydale be arranged during the month of June next.

General Meeting of the members in the Council Room of the Town Hall, Barnsley, on Wednesday, April 21st, 1886.

The chair was occupied by Joseph Mitchell, Esq., C.E., F.G S.

The minutes of the annual meeting were read and confirmed.

The following gentlemen were elected members of the Society:—

Samuel Jury, Huddersfield.
Joseph Field, Huddersfield.
Chas. Hy. Bould, Huddersfield.
Geo. Harrison, Huddersfield.
M. B. Slater, Malton.
E. Wareham Harry, C.E., Harrogate.
Chas. Pole, Halifax.
Mark Pole, H.M. Inspector of Schools, Halifax.

Mr. Davis proposed and Mr. Lister seconded that Mr. Ormerod be elected Hon. Local Secretary for Brighouse.

The Chairman gave an address on the recently published Report of the Mining Commission and on Explosions in Mines.

The following papers were read:—

1. "On some remarkable properties in the Characteristic Constituent of Steel." By H. Clifton Sorby, Esq., LL.D., F.R.S.
2. "On Fossil fructifications from the Yorkshire Carboniferous Rocks." By Wm. Cash, Esq., F.G.S.
3. "On the Polyzoa of the Wenlock Shales." By G. R. Vine, Esq.
4. "On the exploration of a Cave in Wensleydale." By W. Horne, Esq.
5. "On Acrespore." By H. B. Stocks, Esq.

Mr. R. Carter proposed a vote of thanks to the authors of the papers. The motion was seconded by Mr. Thos. Lister, supported by the Chairman, and carried unanimously. Dr. Sorby replied.

Proposed by the Hon. Secretary, seconded by Mr. Thos. Ormerod, that the thanks of the members be given to the Mayor and Corporation of Barnsley for the use of the Council Room.

Proposed by Mr. Cheetham, seconded by Mr. Peach and carried, that the next meeting be held at Leyburn, and that it be followed by an excursion in Wensleydale.

Proposed by Dr. Sorby, seconded by Mr. Carter and carried, that the best thanks of the meeting be given to Mr. Mitchell, the chairman, for presiding. The Chairman replied.

The members afterwards dined at the Queen Hotel.

General Meeting at Leyburn, Aug. 11th, 1886.

An excursion of the members of the Society took place on Wednesday and Thursday, Aug. 11th and 12th, 1886, in Wensleydale. On the first day the members met at Hawes, and under the guidance of Dr. F. A. Lees and W. Horne, Esq., visited Cotter Force and Hardraw Scar, thence by rail to Aysgarth. The geological features of the district were explained, and a number of fossil remains were obtained. Mr. Rodwell, of Redmere, pointed out a vein of lead ore

which has been worked above the Upper Fall at Aysgarth. The lower falls were also visited. The party arrived by train at Leyburn at 7.15 and proceeded to the Bolton Arms Hotel, where dinner was provided. Sir Charles Dodsworth presided at the dinner, and also at a duly constituted meeting of the members.

The minutes were read and confirmed.

The following gentlemen were elected members :—

J. Arthur Binns, 11, Oak Lane, Manningham, Bradford.
Richard Sugden, Ye Farre Close, Brighouse.
T. W. H. Mitchell, Barnsley.
Jas. Taylor, Borough Surveyor, Barnsley.
Rev. W. W. Kirby, M.A., Rector of Barnsley.
Surr Wm. Duncan, Horsforth Hall, Horsforth, near Leeds.

A vote of thanks to the chairman concluded the meeting.

On the second day, under the guidance of Wm. Horne, Esq. (T. W. Orde-Powlett, Esq., was unavoidably absent), the members proceeded to the Shawl and inspected a burial ground and ancient tumulus. A small cave explored by the gentlemen named was also visited, and the party proceeded thence to Redmire, inspecting en route the site of an old village, the history of which all trace has been lost. At Redmire, under the guidance of W. Rodwell, Esq., the lead mines were seen, and the operations involved in the crushing, extracting, and smelting the lead were explained. The members then proceeded by rail to Bolton Castle for the purpose of seeing the interesting geological remains which Mr. Powlett has collected and deposited there, amongst others the remains of man and his work which have been obtained from the cave under the Shawl. The railway again conveyed the members to Leyburn, and after lunch at the Bolton Arms they parted to their respective destinations. A hearty vote of thanks was accorded to Mr. Horne for his kind attention and for exhibiting his unique collection of limestone fish remains to the members.

Meeting of the Council at the Museum, Leeds, on Wednesday, October 6th, 1886.

Present, T. W. Embledon, Esq., in the chair; Messrs. Carter, Cheetham, Tate, and Davis. Apologies from R. Reyholds and W. Rowley.

The Minutes were read and confirmed.

The following accounts were ordered to be paid:—

	£	s.	d.
Messrs. A. Megson and Sons - -	68	19	10
„ Whitley and Booth - - -	7	1	6
	£76	1	4

Moved by Mr. Carter, seconded by Mr. Tate, and carried, "That the annual meeting be held at Wakefield on November 16th, 1886, and that Mr. T. W. Embledon, M.E., be requested to preside. The meeting to be held at the Bull Hotel, at 3 p.m., and that papers be accepted from the Rev. J. M. Mello, J. R. Mortimer, Rev. J. Stanley Tute, B.A., J. W. Davis, R. Reynolds, G. R. Vine, and Jno. Holmes.

Meeting of the Council at the Bull Hotel, Wakefield, Nov. 17th, 1886.

W. Cheetham, Esq., in the chair. Present: Messrs. Reynolds, Eddy, Bedford, Adamson, Tate, Lister, Embleton, Rev. E. M. Cole, R Carter, and Davis.

Minutes of last meeting read and confirmed.

Moved by the Hon. Secretary, seconded by Mr. Eddy and carried. That a photograph of the fossil tree at Clayton be issued with the proceedings for next year.

The question of investing a portion of the funds of the Society was considered, and it was decided to defer the subject to the next meeting of the Council.

It was decided to recommend that Mr. T. H. Gray be elected a member of the Council, in place of Mr. W. S. Ward, deceased.

Annual Meeting at Bull Hotel, Wakefield, on Wednesday, Nov. 17th, 1886.

T. W. Embledon, Esq., M.E., occupied the chair.

The minutes of the last meeting were read and confirmed.

The Hon. Secretary presented his Annual Report and the Treasurer's Balance Sheet.

On the motion of the Chairman, seconded by R. Carter, Esq., the Report and Balance Sheet were adopted.

Mr. S. A. Adamson proposed and Mr. Gray seconded that

Harry Lupton, Esq., The Grange, Horsforth,
C. Brownbridge, Esq., F.G.S., Horsforth,
— Fennel, Wakefield,

be elected members of the Society. Carried.

Jas. W. Davis proposed and Mr. Cheetham seconded that S. A. Adamson, Esq , F.G.S., be Hon. Local Secretary for Leeds. Carried.

Proposed by Mr. Cheetham, seconded by Mr. Tate, and carried, that the Marquis of Ripon be re-elected President, and that the Vice-Presidents be re-elected, viz.:—

Duke of Leeds.	Viscount Galway.
Earl of Dartmouth.	Louis J. Crossley, J.P.
Earl Fitzwilliam.	W. Morrison, M.P.

Earl of Wharncliffe.	Thos. Shaw, M.P.
Lord Houghton.	Thos. W. Tew, J.P.
Viscount Halifax.	H. C. Sorby, F.R.S.

W. T. W. S. Stanhope, J.P.

Proposed by Mr. J. E. Bedford, seconded by Mr R. Reynolds, that Mr. W. Cash be re-elected Treasurer, and that Mr. Jas. W. Davis be re-elected Honorary Secretary. Carried.

Proposed by Mr. Thos. Lister, seconded by Mr. Jas. Booth, and carried, that the following gentlemen be the Council for the ensuing twelve months:—

W. Alexander, M.D.	Prof. A. H. Green, M.A.
J. E. Bedford.	Thos. H. Gray.
R. Carter, C.E.	Geo. H. Parke.
W. Cheetham.	R. Reynolds.
J. R. Eddy.	W. Rowley.
T. W. Embleton.	C. Fox-Strangways.

The Chairman gave a short description of a paper on the History of Coal Mining, which will be printed in the proceedings.

The following papers were read:—

1. Prof. A. Lupton, C.E., F.G.S., on "Safety Lamps."
2. J. R. Mortimer, Esq., F.G.S., on "Habitation Terraces in the East Riding of Yorkshire."
3. Rev. J. S. Tute, B.A., on "The Cayton Gill Beds."
4. Rev. J. Magnus Mello, M.A., on "The Microscopical Study of Rocks."
5. James W. Davis, on "The Relative Age of the Remains of Man in Yorkshire."
6. Jno. Holmes, Esq., "Pre-historic Remains on Rombalds Moor."
7. Geo. R. Vine, Esq., Notes on the Palæontology of the Wenlock Shales of Shropshire."
8. Jas. W. Davis, Esq., "Report on the Raygill Fissure."
9. Richard Reynolds, Esq., F.C.S., on "An Abnormal Barometrical Disturbance in Yorkshire, in 1883-4, and on the Eruption of Krakatoa."

Mr. Davis proposed and Mr Eddy seconded that a vote of thanks be accorded to Mr. Spencer, the proprietor of Ray-Gill Fissure, and to Mr. Todd, his manager, for their great help and uniform kindness. Carried.

Votes of thanks to authors and chairman terminated the meeting.

The members dined together.

Summary of Geological Literature relating to Yorkshire, Published during 1885-6.

Compiled by **JAMES W. DAVIS.**

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——— ———Note on the parallel roads of Glen Gloy. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix, p. 123.

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——— ———Note on Chlamydoselachus anguineus, Garman. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix, p.98, pl. xi.

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Sheet 133—Darlington and Osmotherley Moor to Easingwold.
" 135—Upsall to Gristhorpe Bay.
" 137—Knaresborough to Robin Hood's Bay.
" 138—Sections illustrating the structure of the Oolites of the Howardian Hills.
" 139—Western escarpment of the Wolds to Brough, on the Humber.

Maps—1 in. to mile.
96 S. W., Thirsk.
96 N. W., Northallerton.
93 S. E., Selby.

Drift Geology—1 in. to mile.
96 N. W., Northallerton.
96 S. W., Thirsk.
93 S. E., Selby.
103 S. W., Barnard Castle.

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LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*).

*Abbott, R. T. G., Quarry Cottage, Norton, Malton.
Adamson, S. A., F.G.S., 52, Well Close Terrace, Leeds.
Akroyd, Ed., F.S.A., &c., Halifax.
*Aldam, W., J.P., Frickley Hall, Doncaster.
Alexander, Wm., M.D., J.P., Halifax.
Anderton, C. P., Cleckheaton.
Atkinson, J. T., F.G.S., The Quay, Selby.

Bailey, Geo., 22, Burton Terrace, York.
Baines, Sir Edward, J.P., St. Ann's, Burley, Leeds.
Balme, E. B. W., J.P., Cote Hall, Mirfield.
Barber, W. C., F.R.G.S., The Orphanage, Halifax.
Bartholomew, Chas., Castle Hill House, Ealing, Middlesex.
*Bartholomew, C. W., Blakesley Hall, near Towcaster.
Bayley, Rev. T., Weaverthorpe.
Beaumont, Hy., Elland.
Bedford, James, Woodhouse Cliff, Leeds.
Bedford, J. E., Clifton Villa, Cardigan Road, Leeds.
Berry, Wm., King Cross Street, Halifax.
Binnie, A. R., F.G.S., M. Inst. C.E., Town Hall, Bradford.
Binns, J. A., 11, Oak Lane, Manningham.
Booth, James, F.G.S., Springhall, Halifax.
Boothroyd, W., Brighouse.
Bould, Charles H., Halifax Old Road, Huddersfield.
*Bowman, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S., Halifax.
Bradley, George, Aketon Hall, Featherstone.
Brierley, H. G., East View, Huddersfield.
*Brigg, John, J.P , F.G.S , Keighley.
*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.
Broadhead, John, St. John's Colliery, Normanton.
Brooke, Ed., jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
Brooke, Lieut.-Col. Thos., J P., Armitage Bridge, Huddersfield.

Browbridge, C., C.E., F.G.S., Horsforth, Leeds.
*Buckley, George, jun., Waterhouse Street, Halifax
Butler, J. Dyson, Estate Buildings, Huddersfield.

Carr, Wm., Halifax.
Carter, Jas , Burton House, Bedale.
Carter, R., C.E.. F.G.S., Springbank, Harrogate
*Cash, W., F.G.S., Elmfield Terrace, Halifax.
Chadwick, Wm., Arksey, Doncaster.
*Charlesworth, J. B., J.P., Wakefield.
Cheetham, W., Horsforth, near Leeds.
*Clark, J. E., B.A., B.Sc., F.G.S., 20, Bootham, York.
Cole, Rev. E. Maule, M.A., Wetwang Vicarage, near York.
Crossley, Lieut.-Col. Louis J., J.P., F.R.M.S., Moorside, Halifax.
Crowther, F., Northowram, near Halifax.

*Dakyns, J. R , M.A., of H.M. Geological Survey, 28, Jermyn Street, London, W.
Dalton, Thos., Albion Street, Leeds.
Dartmouth, Earl of, Patshull House, Wolverhampton.
Davey, Hy., Rupert Lodge, Leeds.
Davidson, J., F.C.S., Holywell Green, near Halifax.
*Davis. James W., F.S.A., F.G.S., F.L.S , Chevinedge. Halifax.
Davis, R. Hayton, F.C.S., Harrogate.
*Denham, Charles, London.
Dewhurst, J. B., Aireville, Skipton.
Dobson, M. G., Stannary Hall, Halifax.
Dodsworth, Sir Charles, Bart., Thornton Watlass, Bedale.
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*GAUKROGER, W., Fernside, Halifax.
GLEADHOW, F., Sutton, near Alford, Lincolnshire.
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GOUGH, W. C., Wykeham, York.
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GREGSON, W., Baldersby, Thirsk.

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HALLILAY, J., Burley Road, Leeds.
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HARRISON, GEORGE, East View, Huddersfield.
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HIRST, JOHN, Tadcastle, Dobcross, Saddleworth.
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Horne, Wm., Leyburn

Houghton, Lord, Fryston Hall, near Pontefract.

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Hunt, H. J., Surgeon, Harrogate.

Jury, Samuel, Halifax Old Road, Huddersfield.

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Kell, Geo., Barnsley.

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Learoyd, S., F.G.S , Sherwood House, Huddersfield.

Leather, J. T., Leventhorpe Hall, near Leeds.

Lee, P. F., West Park Villas, Dewsbury.

Lee, J. Banks, Ripon.

Leeds, Duke of, Hornby Castle, Bedale.

Lister, Thomas, Victoria Crescent, Barnsley.

Lowther, Sir Charles, Bart., Swillington Park, near Leeds.

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Lund, Percy, Ilkley.

Marriott, C. H., J.P., Manor Lawn, Dewsbury.

Marsden, Thos., Paper Mills, Barnsley.

Marshall, John, F.G.S., Walsden, near Todmorden.

Marshall, Stephen A., B A , Weetwood, near Leeds.

McLandsborough, J , F G S , F R A S., &c , Manningham, Bradford.

Middleton, Charles, Lord Street, Halifax.

Milne, S. Milne, Calverley House, near Leeds.

Mitchell, John, Swaith Hall, near Barnsley.

MITCHELL, JOSH , F.G.S., Worsbro' Dale, Barnsley.

MITCHELL, T. CARTER, Topcliff, Thirsk.

MITCHELL, T. W. H., Barnsley.

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NEWHOUSE, WM. HY., Brighouse.

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ORMEROD, HANSON, Boothroyd, Brighouse.

ORMEROD, THOMAS, Brighouse.

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POLE, CHARLES, Halifax.

POLE, M., H.M Inspector of Schools, Sowerby Bridge, Halifax.

POLLOCK, Rev. Dr., Cundall Vicarage, Boroughbridge.

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REUSS, F. W., Dewsbury

REYNOLDS, RICHARD, F.C.S., Cliff Lodge, Leeds.

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Scratcherd, T. C., Halifax.

Seal, Stephen, F.G.S., Darfield Quarries, Barnsley.

Sharp, C. Forbes, Driffield.

Shaw, John, Darrington Hall, Pontefract.

Shaw, Thomas, M.P., D.L., J.P., Allangate, Halifax.

Sladen, W. P., F.G.S., F.L.S., Orsett House, Ewell, Surrey.

Slater, E., Ashville, Stanningley, Leeds.

Slater, M. B., Malton.

Slingsby, W. C., Carleton, near Skipton.

Smith, F., Huddersfield Road, Halifax.

Smithies, J. W., Elland.

Sorby, H. C., D.C.L., F.R.S., F.G.S., Broomhill, Sheffield.

Stanhope, W. T. W. S., J.P., Cannon Hall, Barnsley.

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Swallow, D., Gas Works, Bradford.

Sykes, Peace, 33, Estate Buildings, Huddersfield.

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Taylor, Jas., Borough Surveyor, Barnsley.

Tennant, J. R., 62, Brunswick Place, Brighton.

Tetley, Mrs., Foxhills, Weetwood, Leeds.

Tetley, C. F., Spring Road, Headingley, Leeds.

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Townend, Walter, Lightcliffe, near Halifax.

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TUTE, Rev. J. STANLEY, B.A., Markington, Ripley.

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VILLIERS, J., Eastgate, Beverley.

VINE, GEORGE R., 113, Hill Top, Attercliffe, Sheffield.

WALKER, CHARLES, Little Houghton, Darfield.

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WARD, CHRISTOPHER, F.L.S., F.Z.S., Halifax.

*WARD, J. WHITELEY, J.P., F.R.M.S., South Royd, Halifax.

WARD, JOHN, F.G.S., 23, Stafford Street, Longton, Staffordshire.

WHARNCLIFFE, Earl of, Wortley Hall, Sheffield.

WHEATLEY, CHARLES, Sands House, Mirfield.

*WHITELEY, FREDK., Clare Road, Halifax.

WILSON, E. J., M.A., 6, Whitefriars' Gate, Hull.

WOODALL, J. W., J.P., F.G.S., Old Bank, Scarborough.

WOODHEAD, JOSEPH, J.P., Woodthorpe, Huddersfield.

*** It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1886.

Sheet 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, Assoc. M. Inst. C.E., F.R.Met.Soc., F.G.S.

Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Pressure of Atmosphere in Month.

Months	Highest Reading of Barometer	Date	Mean of Highest of 18 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 18 Years	Range	Corrected for Capillarity and Temperature: Mean	Mean of 18 Years
	Ins	On	Ins	Ins	On	In	Ins	Ins	Ins
January	[illegible]	7th	30.1[illegible]	28.597	18th	2[illegible]	1.146	2[illegible]	29.504
February	30.248	9[illegible]	30.0[illegible]	28.[illegible]40	1st	2[illegible].710	1.518	2[illegible]	[illegible]
March	3[illegible]	11th	[illegible]	28.801	2nd	[illegible]	1.[illegible]	2[illegible]	[illegible]
April	[illegible]	1[illegible]th	[illegible]	[illegible]	[illegible]th	[illegible]	1.[illegible]	2[illegible]	2[illegible].474
May	[illegible]	[illegible]th	[illegible]	2[illegible].67	13th	2[illegible].015	1.11[illegible]	2[illegible]	2[illegible]
June	[illegible]	30th	[illegible]	[illegible]	2[illegible]	2[illegible].15[illegible]	0.67[illegible]	2[illegible].71	[illegible]
July	[illegible]	[illegible]	2[illegible]	[illegible]	14th	2[illegible]	[illegible]	2[illegible]	2[illegible].513
August	[illegible]	20th	2[illegible]	[illegible].119	1[illegible]th	2[illegible].07[illegible]	0.8[illegible]	2[illegible]	[illegible]
September	3[illegible]	16th	3[illegible].07[illegible]	29.3[illegible]0	10th	[illegible]	0.9[illegible]2	[illegible]	[illegible].406
October	[illegible]	24th	30.11[illegible]	[illegible]	15th	2[illegible].72[illegible]	1.70[illegible]	[illegible].71	2[illegible].41[illegible]
November	30.[illegible]5	21th	[illegible]	[illegible].21	6th	[illegible]	1.8[illegible]	2[illegible].113	2[illegible].44[illegible]
December	[illegible]	31st	3[illegible].10[illegible]	[illegible].52	8th	[illegible]	2.5[illegible]3	[illegible]	2[illegible].461
Means, or totals	30.0[illegible]		3[illegible].65	[illegible]		28.[illegible]	1.330	29.4[illegible]	2[illegible].491

Temperature of Air in Shade during Month.

Months	Highest	Date	Mean of Highest daily of 18 Years	Lowest	Date	Mean of Lowest daily of 18 Years	Range	In Each Month: Of all Highest	Mean of 18 Years	Of all Lowest	Mean of 18 Years	Daily Range: Mean	Mean of 18 Years	Of Dry Bulb: Mean	Mean of 18 Years
	Deg	On	Deg	Deg	On	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	51.7	4th	52.8	21.5	2[illegible]th	23.6	30.2	33.5	42.9	31.2	34.3	8.3	[illegible]	35.4	[illegible]
February	46.2	11th	53.5	25.4	27th	26.3	29.8	33.9	44.5	3[illegible]	35.6	7.4	8.9	[illegible]	40.0
March	5[illegible]	[illegible]th	5[illegible]	[illegible]7.4	7th	[illegible]6	42.2	42.[illegible]	[illegible]	33.4	[illegible]	[illegible]	11	33.2	4[illegible].7
April	6[illegible]	[illegible]th	[illegible]5.0	3[illegible].2	[illegible]th	31.3	35.8	5[illegible].8	5[illegible].1	30.4	[illegible]	12.4	13.4	43.1	[illegible]
May	[illegible]	[illegible]th	[illegible]	3[illegible].6	2nd	3[illegible]	[illegible]5.4	5[illegible].1	5[illegible]	4[illegible]	[illegible]	[illegible]	14.7	48.8	49.4
June	[illegible]	2[illegible]th	[illegible]	40.4	4th	41.7	31.2	61.9	6[illegible]	4[illegible]	[illegible]	13.4	15.1	54.[illegible]	55.[illegible]
July	[illegible]5	[illegible]	[illegible]	4[illegible]	10th	46.9	[illegible]	6[illegible].1	6[illegible].7	5[illegible]	[illegible]	13.3	14.7	5[illegible].1	60.[illegible]
August	7[illegible]	31st	7[illegible].6	41.6	[illegible]	45.[illegible]	34.[illegible]	67.1	[illegible].6	54.0	[illegible]	13.1	14.3	59.5	[illegible]
September	76.4	1st	7[illegible]	40.2	23rd	40.2	36.2	6[illegible].9	[illegible].2	50.8	[illegible]	12.[illegible]	12	5[illegible]	54.[illegible]
October	5[illegible]	1st	[illegible].8	[illegible].0	2[illegible]th	32.3	31.2	5[illegible].1	64.1	47.0	[illegible]	9.1	10.6	[illegible]1.1	48.4
November	53.2	1st	[illegible].5	33.1	22[illegible]	28.4	24.[illegible]	4[illegible].7	[illegible].3	40.8	[illegible]	7.9	9.1	41.5	[illegible].7
December	51.2	[illegible]th	5[illegible]	2[illegible].6	1[illegible]th	23.1	23.6	4[illegible]	42.[illegible]	32.[illegible]	[illegible]	[illegible]	8.4	[illegible]	[illegible]
Means, or totals	[illegible]		64.9	2[illegible].5		[illegible]	3[illegible].1	5[illegible]	51.4	42.1	[illegible]	[illegible]	11.8	[illegible]	[illegible]

Adopted Mean Temperature.

Months	Of Air: Mean	Mean of 18 Years	Of Evaporation: Mean	Mean of 18 Years	Dew Point: Mean	Mean of 18 Years
	Deg	Deg	Deg	Deg	Deg	Deg
January	35.4	33.7	34.2	37.6	32.3	31.8
February	35.0	[illegible]	[illegible]	3[illegible].1	3[illegible].9	[illegible]
March	3[illegible].6	40.3	3[illegible].0	[illegible]	[illegible]	[illegible]
April	43.1	45.1	4[illegible]	41.[illegible]	36.5	[illegible]
May	4[illegible]	4[illegible]	[illegible]	45.[illegible]	4[illegible].4	4[illegible]
June	[illegible]	[illegible]	44.6	51.1	44.8	4[illegible].7
July	59.0	60.1	51.0	54.5	49.5	5[illegible]
August	59.1	58.9	51.6	54.2	50.6	50.5
September	55.7	54.8	[illegible]	51.4	[illegible].9	4[illegible].1
October	50.8	4[illegible].1	41.5	45.8	43.1	43.1
November	44.4	42.[illegible]	[illegible]	40.1	38.9	[illegible]
December	[illegible]	38.7	34.5	3[illegible].7	32.1	[illegible]
Means, or totals	[illegible]	[illegible]	[illegible]	44.5	4[illegible].6	41.2

Vapour.

Months	Elastic Force: Mean	Mean of 18 Years	In a Cubic Foot of Air: Mean	Mean of 18 Years	Short of Saturation: Mean	Mean of 18 Years	Mean Weight of a Cubic Foot of Air	Mean of 18 Years
	Ins	Ins	grs	grs	grs	grs	grs	grs
January	184	204	2.1	2.4	0.3	[illegible]	517	519
February	[illegible]	21[illegible]	2[illegible]	2	0.3	[illegible]	[illegible]	[illegible]
March	194	[illegible]	2.2	[illegible]	0.4	[illegible]	5[illegible]	[illegible]
April	[illegible]	240	[illegible]	[illegible]	0.7	[illegible]	5[illegible]1	[illegible]11
May	251	25[illegible]	[illegible]	[illegible]	1.0	[illegible]	[illegible]	[illegible]
June	[illegible]	[illegible]19	[illegible]	[illegible]	1.4	1.4	[illegible]	531
July	[illegible]51	367	[illegible]	4.1	1.6	1.7	524	[illegible]
August	36[illegible]	[illegible]	4.2	4.[illegible]	1.5	1.5	527	5[illegible]6
September	3[illegible]6	[illegible]	3[illegible]	[illegible].8	1.2	1.0	53[illegible]	[illegible]
October	[illegible]	27[illegible]	3[illegible]	3[illegible]	1.4	0.[illegible]	[illegible]2	[illegible]
November	2[illegible]8	223	[illegible]	[illegible]6	0.6	0.5	[illegible]	514
December	[illegible]2	1[illegible]	2.1	[illegible]	0.4	0.4	[illegible]	518
Means, or totals	[illegible]	[illegible]	3.0	[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]

Degree of Humidity (Complete Saturation = 100)

Months	Highest	Date	Mean of Highest of 18 Years	Lowest	Date	Mean of Lowest of 18 Years	Mean	Mean of 18 Years
	0–100	On	0–100	0–100	On	0–100	0–100	0–100
January	[illegible]	12th	97	70	[illegible]th	[illegible]	[illegible]	86
February	[illegible]7	[illegible]th	97	[illegible]	15th	[illegible]	8[illegible]	86
March	[illegible]	2nd	[illegible]	[illegible]	[illegible]	7	[illegible]	83
April	[illegible]	7th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	78
May	[illegible]	9th	9[illegible]	[illegible]	4th	15	[illegible]	73
June	[illegible]4	1st	9[illegible]	46	24th	49	[illegible]	72
July	97	6th	91	15	[illegible]	[illegible]	[illegible]	70
August	9[illegible]	23rd	92	48	[illegible]th	52	[illegible]	74
September	96	10th	9[illegible]	49	[illegible]th	56	76	78
October	[illegible]	5th	[illegible]	65	2[illegible]th	[illegible]	91	83
November	97	5th	9[illegible]	63	1[illegible]th	[illegible]	81	83
December	[illegible]	2nd	9[illegible]	63	[illegible]	[illegible]	[illegible]	85
Means, or totals	[illegible]		9[illegible]	5		3	[illegible]	[illegible]

Bright Sunshine. — Temperature of Air in Sun's Rays.

Months	Greatest Daily Duration	Date	Total of Month	Percentage of Possible Duration	Highest	Date	Mean of Highest of [illegible] Years	Mean	Mean of 18 Years
	hr. min.	On	hr. min.		Deg	On	Deg	Deg	Deg
January	4 30	9th	[illegible]4 1	10	6[illegible].0	1[illegible]th	[illegible]0.2	48.7	47.[illegible]
February	6 15	3rd	35 45	1[illegible]	65.6	15th	[illegible]	5[illegible].5	52.[illegible]
March	7 5	7th	38 [illegible]	11	[illegible]	26th	[illegible]	59.[illegible]	[illegible]
April	8 30	28th	95 28	23	85·8	28th	97.5	69.8	73.2
May	10 10	7th	[illegible]2 1[illegible]	17	[illegible]3.2	7th	105.[illegible]	7[illegible]	81.3
June	10 30	16th	103 40	21	101·0	29th	111·3	83·4	87.5
July	11 45	6th	142 31	28	108·8	5th	114.0	89·7	91·0
August	9 20	1[illegible]	[illegible] 2[illegible]	9	[illegible]	18th	[illegible]	[illegible]8.8	89.5
September	7 50	8th	92 38	25	98·8	1st	99.0	83·0	[illegible]0·7
October	6 [illegible]	[illegible]	[illegible] 35	[illegible]	[illegible]	4th	[illegible]5	[illegible]7	[illegible]
November	4 50	19th	[illegible]5 10	1[illegible]	72.5	15th	[illegible]	[illegible]5	[illegible]5.4
December	4 15	2[illegible]th	[illegible]4 46	15	[illegible]	11th	[illegible]7.3	4[illegible].9	[illegible].8
Means, or totals	7 35		851 48	19	[illegible]4.4		[illegible]1	[illegible]9.8	[illegible]9.7

Wind.

Months	Direction: Relative Proportion of at 9 a.m.: N	NE	E	SE	S	SW	W	NW	Pressure: Mean at 9 a.m.	Mean of 3 Years	Mean of all Daily Highest	Mean of all Daily Highest of 3 Years	Highest	Direction	Date	Mean of Highest of Month of [illegible]
	No	No	No	No	No	No	No	No	lb. per sq. ft	lb. per sq. ft	lb. per sq. ft	lb. per sq. ft	lb. per sq. ft		On	lb. per sq. ft
January	5	6	3	2	0	4	4	8	1.1	1.[illegible]	4.12	4.21	12.75	W	4th	15.25
February	5	7	2	5	1	2	1	5	0.4	[illegible].8	1.30	3.10	9.09	W	2nd	10.33
March	[illegible]	9	0	4	[illegible]	6	2	2	1.1	0.8	2.1[illegible]	2.46	11.0[illegible]	S S W	27th	12.17
April	8	3	1	4	2	5	5	2	1·0	0·8	3.97	2·69	17.00	S S W	1st	10.25
May	4	5	3	2	5	7	2	3	0.8	1.0	2.24	[illegible].87	[illegible].00	W	16th	9.33
June	6	3	0	4	2	3	9	3	1·0	0·6	2·60	1·07	12.00	W	16th	7·67
July	4	2	0	1	3	8	7	6	1·0	0·7	2.89	1·95	10.00	W	15th	5.92
August		2	2	0	[illegible]	7	8	[illegible]	0.6	[illegible]6	1.71	1.94	6.[illegible]0	[illegible] W	27th	7.00
September	2	2	6	1	2	8	2	8	0.9	1.0	2.42	2·74	8.00	S W	9th	8.60
October	[illegible]	[illegible]	5	6	5	1	5	1	0.6	0.8	1.[illegible]	3.26	11.[illegible]	[illegible]	15th	1[illegible].[illegible]8
November	5	1	1	1	[illegible]	10	6	4	0.5	0.7	2.25	2.44	10.0[illegible]	S W	4th	11.33
December	7	3	1	1	1	2	[illegible]	0	0.[illegible]	0.8	[illegible].66	3.[illegible]	1[illegible]	W S W	9th	15.0[illegible]
Means, or totals	[illegible]9	45	24	3[illegible]	[illegible]0	[illegible]4	[illegible]	66	0.3	0.8	2.58	2.8[illegible]	11.10			10.45

Rain.

Months	Mean Amount of Cloud	Number of Days of Rain	Amount Collected	Greatest Daily Fall	Date	Mean of 17 Years	Mean of Seven Years ending with 1882, 65ft above surface of ground	Mean [illegible] with Town Hall and Midland Railway Station on surface of ground	Gr'ter fall on surface at Town Hall & Mid. Stn. than at 65ft. above surface at Exch.: Depth in Inches	Percentage of fall at Exch'ge
	0–10	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	8.[illegible]	23	5.22	[illegible].98	26th	2.8[illegible]	2.209	2.1[illegible]4	0.265	11.2
February	8.4	8	[illegible]	0.29	2nd	2.02	2.1[illegible]9	2.[illegible]2	0.303	11.[illegible]
March	7.6	19	[illegible].25	[illegible]	2nd	2.[illegible]	2.776	[illegible]	0.[illegible]1	11.7
April	6·7	23	2.16	0·47	9th	2·18	2.616	2.835	0·319	11·2
May	7.8	19	4.64	1.[illegible]8	13th	1.81	2.103	[illegible].277	0.174	10.8
June	7·9	6	0.97	0.63	2nd	2.62	2.837	3.011	0·174	10·6
July	6·8	16	4·85	2·13	26th	3.06	3·401	3.641	0.240	10·7
August	6.6	17	1.[illegible]2	0.27	10th	2.[illegible]1	[illegible]	[illegible].92	[illegible]3	1[illegible].7
September	7·0	13	1·63	0.42	10th	2.90	2.894	3.229	0.335	11.2
October	8.4	24	4.[illegible]	0.[illegible]5	2nd	[illegible]	[illegible]	4.[illegible]12	0.3[illegible]2	11.[illegible]
November	7.4	11	1.[illegible]9	0.74	6th	2.8[illegible]	[illegible].121	[illegible]	0.49[illegible]	11.2
December	7.7	26	4.[illegible]6	0.62	12th	2.63	[illegible].681	4.17[illegible]	0.489	11.3
Means, or totals	7.5	205	3[illegible]	0.[illegible]		[illegible]	[illegible]5.711	[illegible]0.601	[illegible]0	11.05

METEOROLOGY OF BRADFORD FOR 1886.

Sheet 2.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year	Pressure. Highest. Reading of Barom. during Year.	Date.	Pressure. Lowest. Reading of Barom. during Year.	Date.	Temperature. In Shade. Highest. R'ding of Max. Thermom. during Yr.	Date.	In Shade. Lowest. R'ding of Minimum Thermom. during Yr.	Date.	Last and First Frost of Seasons. Date of Last Frost.	Date of First Frost.	In Sun's Rays. Highest. Reading of Solar Thermom. during Yr.	Date.	Humidity (Complete Saturation = 100). Highest. Degree of Humidity during Yr.	Date.	Lowest. Degree of Humidity during Yr.	Date.
	Ins.		Ins.		Deg.		Deg.				Deg.		0 = 100		0 = 100	
1869	30 290	Dec 6	28 500	Feb. 1	86·2	Aug. 30	19 8	Dec 28	Mar. 27	Oct. 20	127 7	Aug. 30	99	Feb. 8	42	Sep 24
1870	[illegible]	Jan 19	[illegible]	Jan 8	85 0	[illegible]	16 6	[illegible]	Mar. 30	Nov 9	127 5	[illegible]	[illegible]	Jan 29	40	[illegible]
1871	[illegible]	[illegible]	[illegible]	Jan 16	[illegible]	[illegible]	[illegible]	Jan 1	April 11	Nov 14	[illegible]	[illegible]	[illegible]	July 7	[illegible]	[illegible]
1872	30 156	April 6	28 070	Jan 24	86 4	July 23	24 8	Mar. 27	Mar 27	Nov. 19	124 8	Aug. 19	100	Mar. 22	45	Sep. 23
1873	[illegible]	[illegible]	[illegible]	Jan 20	[illegible]	[illegible]	[illegible]	[illegible]	Mar 14	Nov 5	124 5	[illegible]	100	Dec 11	41	[illegible]
1874	[illegible]	[illegible]	[illegible]	Dec 11	[illegible]	[illegible]	15 0	Dec 31	Mar 12	Nov 11	[illegible]	[illegible]	100	Feb 6	[illegible]	May 18
1875	30 305	July 7	28 484	Nov 10	80·0	Aug. 17	13·0	Jan 1	Mar 22	Nov 26	122 0	July 6	100	Jan 23	43	July 6
1876	[illegible]	Jan 15	[illegible]	[illegible] 4	[illegible]	[illegible]	[illegible]	[illegible]	April 15	[illegible]	[illegible]	[illegible]	[illegible]	Oct 4	46	[illegible]
1877	[illegible]	Oct 6	[illegible]	Nov 29	[illegible]	June 19	[illegible]	Mar 1	May 4	Oct 16	[illegible]	[illegible]	100	[illegible]	[illegible]	[illegible]
1878	[illegible]	[illegible]	[illegible]	April 1	[illegible]	[illegible]	[illegible]	[illegible]	April 6	[illegible]	[illegible]	[illegible]	99	[illegible]	[illegible]	[illegible]
1879	[illegible]	[illegible]	[illegible]	Feb 10	71 4	[illegible]	[illegible]	[illegible]	[illegible]	Nov 14	101 2	[illegible]	100	[illegible]	51	[illegible]
1880	30 332	Jan. 7	28 154	Nov 16	81·3	Sep 6	20·8	Jan 20	Feb. 23	Oct. 20	112·0	Aug. 13	99	Dec. 15	50	May 30
1881	[illegible]	Mar 10	[illegible]	Oct 14	[illegible]	July 6	12 0	[illegible]	April 21	Oct 1	[illegible]	June 1	[illegible]	Oct 14	[illegible]	[illegible]
1882	[illegible]	Jan 18	[illegible]	Mar 1	77 4	Aug 12	[illegible]	Dec 11	[illegible]	Nov 12	106 0	[illegible]	[illegible]	Nov 5	[illegible]	[illegible]
1883	30 500	April 9	28 452	Sep 2	76 2	July 3	19 8	Mar. 10	Mar 29	Nov 12	107 6	May 17	99	Dec 26	30	April 9
1884	[illegible]	[illegible]	[illegible]	Jan 27	84 4	[illegible]	[illegible]	Nov 30	April 24	Nov 24	[illegible]	[illegible]	98	[illegible]	[illegible]	[illegible]
1885	[illegible]	Mar 14	[illegible]	Jan 11	82 2	[illegible]	22 1	Dec 11	April 5	Nov 16	[illegible]	July 27	[illegible]	Jan 23	[illegible]	[illegible]
1886	[illegible]	Nov 24	[illegible]	Dec 8	[illegible]	[illegible]	[illegible]	Mar 7	[illegible]	Dec 2	[illegible]	July 5	[illegible]	[illegible]	[illegible]	May 1
Means	[illegible]		[illegible]		82 6		17 9				[illegible]		[illegible]		4[illegible]	

Year	Bright Sunshine. Greatest Daily Duration.	Date.	Total of Year.	Per cent. of Possible Duration.	Wind Pressure. Highest.	Date.	Rain. Total for Year.	Mean Fall at Town Hall and Midland Station (on surface).	Greater fall on surface than at Exchange. Depth in Inches.	Percentage of fall at Exch'ge.	Greatest Daily Fall during Yr.	Date.	Snow. Last and First Snow of Seasons. Date of Last Snow.	Date of First Snow.
	[illegible]		[illegible]		[illegible] sq. ft.		Ins.	Ins.	Ins.	Per cent.	In.			
1869	...	...	...	...		...		......	...	...		......	April 3	Oct. 19
1870							24 120				[illegible]	June 18	[illegible] 24	Nov 15
1871							[illegible]				[illegible]	June 16	[illegible] 15	Nov 16
1872	..	.....	...	...	..	....	42 060	. .	..	.. .	2 490	June 19	May 11	Nov. 13
1873							[illegible]				[illegible]	Aug 4	April 25	Jan. 3, '74
1874							[illegible]				[illegible]	Dec 7	[illegible]	Nov 26
1875	.....	...	..	.....	...	.. .	30 280	.....	..	. ..	1 700	Nov. 15	Mar. 12	Nov. 9
1876							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Oct 9	April 12	Nov 8
1877							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	July 16	[illegible]	Oct 15
1878							[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible] 14	April 1	[illegible]
1879							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 8	[illegible] 7	Nov 20
1880	..	.	.	.	..	. .	35 690	39 616	3 926	11 10	1 710	Oct. 27	Mar. 2	Oct. 27
1881							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 13	April 20	[illegible]
1882							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Dec 6	[illegible] 21	[illegible]
1883	...	.. .	. ....	... ..	.....	.	34 396	.....	.....	.. ..	1 338	Sep 26	Mar 24	Nov 10
1884					[illegible]	[illegible] 24	[illegible]				[illegible]	[illegible]	Feb 28	[illegible]
1885					[illegible]	[illegible]	[illegible]				[illegible]	Sep 3	[illegible]	[illegible]
1886	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	July 26	[illegible]	Nov 6
Means					19		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			

EXPLANATION.

The observations are made at nine a m., and, with the exception of maximum and minimum thermometer readings, again at three p m

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level, the air temperature being 48 degrees and barometer reading 30 inches at sea level, add 401 inch to the heights given

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 6 40 p.m. the mercury of the Exchange barometer had fallen to 27 466 inches only the lowest reading on record here The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The sunshine is recorded in hours and minutes by glass sphere on cards fixed on Professor Stokes' zodiacal frame

The solar thermometer has a black bulb enclosed in a vacuum

The direction and pressure of wind are recorded as indicated by an anemometer fixed 10½ feet above the ridge of roof of Exchange. The pressure is given in pounds avoirdupois per square foot

The amount of cloud is estimated by a scale ranging from 0 to 10

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3 86 inches, or 11 08 per cent, greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the seventeen years ending with 1886 is 31·590 inches By adding 11 08 per cent thereto the mean normal rainfall of central Bradford for such period is found to be 35·090 inches per annum There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange--and on buildings generally--than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof--the place it has since occupied. To avoid risk of inaccurate results the rainfall of 1869 is omitted from these returns

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory

12/1/1921/6 [illegible]

PROCEEDINGS OF THE YORKSHIRE

Geological & Polytechnic Society.

NEW SERIES, VOL. IX., PART III., PP. 337-498.

WITH TWELVE PLATES.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., &c.

1887

PAPERS:— CONTENTS. PAGE.

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1888.

PROCEEDINGS
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1887.

ON THE LARGER BOULDERS OF FLAMBRO' HEAD. *Part I.*

BY G. W. LAMPLUGH.

The boulder-clays and glacial gravels which are everywhere so strongly developed in the coast-sections of Yorkshire, are steadily yielding erratic blocks as the sea cuts back into the cliffs, and these blocks accumulate on the shore in large numbers, although they are constantly being diminished by human agency and by the action of the waves and the weather. They are conveniently placed for study, and I have long thought that it would be worth while to make a careful enumeration of those lying within a given area; and this report is a beginning in that direction. For my purpose I have selected the coast line of Flambro' Head, because of its convenient proximity, and because its cliffs contain many deep and highly interesting drift sections and its shores have less sand and shingle to hide the blocks than most parts of the coast. The present report is a first instalment, dealing only with that part of the cliff and beach which lies between the town of Bridlington Quay and the Danes Dyke Valley, a distance of about three miles; while the total length of the cliff line which I propose to examine exceeds twelve miles, and will take some time to complete.

Within the area dealt with in this paper I examined all the larger boulders which were visible on the beach or in the cliff during

my survey,—no doubt by this time others are to be seen, and some of those I examined are buried under shingle—and measured and catalogued those which had any dimension exceeding twelve inches. In this way I compiled a list of 76 erratics, ranging in size from about one cubic foot to over thirty feet. Though probably all derived from the drift-beds of the cliffs immediately adjoining, where the sections consist chiefly of the Purple boulder clay and inter-stratified gravels, the smaller of these blocks are laid upon a shifting beach, and are thus liable to constant change of size and position, so that it will scarcely be necessary to particularize them; but the larger masses have stood without perceptible change of position for several years to my knowledge, and these I shall describe, so as to guide anyone interested in the subject who may have occasion at some future time to examine them.

On analysis I find that my list contains—

			Per cent.
28	Sandstones and Grits, undoubtedly of Carboniferous age	=	36·7
6	Limestones, undoubtedly of Carboniferous age ...	=	7·9
25	Sandstones, origin uncertain, but suspected to be Carboniferous	=	32·8
3	Limestones, origin uncertain, but either Magnesian or Carboniferous	=	4·0
9	Basalts	=	12·0
4	Gneissic and Schistose Rocks	=	5·3
1	Granite (?)	=	1·3
76			100·0

My knowledge of igneous rocks is unfortunately very imperfect, so that my descriptions of erratics of this class may not be very accurate, but the sandstones and limestones which I have put down as Carboniferous I have recognized either by their contained fossils or by some other well-marked peculiarity. My reason for suspecting that most, if not all, of the 25 dubious sandstones are also Carboniferous is because I have not found among the blocks any recognizably Oolitic sandstone (from which formation it might be supposed from their appearance that some of the rocks had come), though fossiliferous beds and beds with marked peculiarities are so

plentiful in that series; and on the other hand whenever close search has resolved my doubts as to a block, the indications I have found have always gone to prove its age to be Carboniferous; nor are there any Jurassic limestones among the limestones I have examined. Hence I think it probable that all these sandstone and limestone boulders have had one source, and that source the Carboniferous, and therefore that the proportion of Carboniferous rocks in the list may be reckoned at certainly not less than sixty and perhaps as high as eighty per cent. of the whole. Of the remainder of the list twelve per cent. are Basalts, some of which have no doubt also come from the dykes and sills of the Carboniferous; and the remaining five boulders (6·3 per cent.) are igneous rocks, whose origin, though unknown to me, might, I think, be determined by anyone who had studied their parent masses, since they are all possessed of very pronounced characteristics.

It is curious, that though the area under consideration is surrounded on all sides by Secondaries to a minimum distance of sixty miles, I did not come across a single boulder of the requisite size which I could be certain had come from Secondary rocks (ignoring the masses of chalk in the lower glacial gravels, which are scarcely detached from their parent rock), and that the whole of the boulders should be far-travelled. But it must be remembered that I am at present dealing only with *the larger boulders* of the drift, and that a consideration of the smaller stones might give quite different results. It may be, too, that as my work proceeds the relative proportion of the rocks will alter, so that for the present it will be safest to base no conclusions on these results.

In the notes which follow are enumerated the more important boulders on the beach between Bridlington Quay and Danes Dyke selected from a List of Seventy-six.

(The numeral indicates the ordinal position of the block in the original full list. The sign + indicates that the measurement after which it is placed is incomplete owing to the block not being fully exposed.)

No.

5.—*Position*:—Near the drain at Sands Cottage, embedded in Purple clay, four feet above the beach. *Description*:—Greenish calciferous sandstone, fossiliferous,—casts of shells. *Age*:—Car-

boniferous. *Shape and size* :—Cube, with the angles slightly rubbed. 23 inches × 12 × (22 +.)

8.—In the sunk roadway at Sands Lane, apparently in Purple clay Fossiliferous yellow sandstone. Carboniferous. (24 +) × (13 +) × — (Nearly buried.)

12.—About 500 yards north of Potters Hill, on beach near the cliff. Slab of gannister, with rootlets. Carboniferous. 58 × 35 × 13.

15.—Near low water mark, on the sands opposite Sewerby. Mass of Mountain Limestone, much corroded by marine life, but with well-rounded outline, and traces of smoothed surface. Carboniferous. 30 × (42 +) × (36 + .)

16.—Near No. 15. Greenish basalt. Sub-angular ; irregular ; 28 inches × 18 × (12 + .)

18.—Near Nos. 15 and 16. Mountain Limestone. Carboniferous. Rude flat-topped mass, angles worn. 60 inches × 40 × (24 +.)

25.—Near 15. Basalt. Conical ; sub-angular. 34 × 33 × (26 +.)

27.—Near 15, but still lower. Mountain Limestone. Carboniferous. Rude sphere, much hidden, but 30 to 40 inches in diameter.

29.—A little north of 15.—Fine grained sandstone, with fossils. Carboniferous. Rhomboidal. 38 × 33 × 30.

37.—On the beach near the west fence of Sewerby Park, near the cliff. Coarsely crystalline basalt : irregular oval, 41 × 32 × (24 +.)

40.—At low tide opposite Sewerby Park, very conspicuous, resting on chalk-scaurs. Hard calciferous sandstone showing bedding planes, pyramidal, sub-angular, origin dubious, 50 × 46 × 36.

43.—Near Cliff, opposite 'Trespass-board.' Fine mass of gneiss, with much quartz. Colour, in variable patches, pink and gray. Well smoothed and rounded : a flattened slightly oblong disc. 36 × 33 × 24.

47.—About 250 yards east of No. 43, and a little lower on the beach. Curious black crystalline mass, schistose, with gnarled foliation, like gneiss : emits a strong odour under the hammer. Rough spheroid, chipped by cartmen. 30 × 24 × 20.

48.—Nearly opposite 47, at dead low-water. Large conspicuous mass of fine-grained grit, (Carboniferous ?) 68 × 54 × 52.

49—At half-tide, between 47 and 48. Fine-grained black basalt, cubical : seems to have had glaciated facets, but damaged by cartmen. 42 × 36 × 34.

56.—Near Cliff, just east of Sewerby Park. Rounded mass of hard dark-gray gneiss. 29 × 15 × 19.

57.—15 yards further east. Curious block showing junction of a pinkish granitoid rock, with a dark rock with black crystals (Hornblendic granite ?), the pink intruding in veins into the dark rock. Rude spheroid. 28 × 20 × (15 + .)

64.—Near the first group of hard gravel-conglomerate. Fine-grained pale sand-stone (Carboniferous ?),, oblong, rounded, perhaps by the sea. 38 × 25 × 20

69.—Near the second group of conglomerate rocks. Curiously knotted and fissured mass of limestone, in some places very hard and sub-crystalline, and in others soft and rather sandy ; perhaps dolomitized. Magnesian ? Rugged oval. 50 × 38 × 33.

70.—Near 69. Dark greenish basaltic rock, with distinct crystals. Oblong, much worn by sea, but seems to have had glaciated surfaces. 30 × 25 × (15 + .)

72.—20 yards east of easternmost mass of hardened gravel, on beach approaching half-tide. Large irregular mass of green gneiss or schist, with well marked foliation planes. 54 × 40 × (36 + .)

NOTE ON DRY VALLEYS IN THE CHALK.

BY THE REV. E. MAULE COLE, M.A.

The month of January, 1887, will long be remembered on the Chalk Wolds of East Yorkshire, as presenting one of the most curious sights ever witnessed. A succession of frosts had frozen the bare ground so hard, that no rain could penetrate. What little rain fell was quickly converted into ice. The same thing happened with regard to subsequent slight falls of snow. The thermometer was never very low. The snow partially melted and froze again, till the whole was converted into what the Swiss call névé. The roads for miles and miles were a sheet of ice. The turnip-fields and grass lands were also covered with a coat of ice, and on the slopes of the

pastures, where the old ridges and furrows, with their curved outlines like an inverted S,* mark the ancient method of ploughing with a team of oxen, miniature glaciers, half a foot deep, and several feet wide, crept down the furrows to join the ice-sheet in the broad bottom below.

On a sudden came a rapid thaw; and in a few hours the dale bottoms were converted into roaring torrents, in some cases 3 feet deep. The ground was still frozen hard underneath. The melting snow could not penetrate, and so "rivers ran in dry places." In some villages, lying in hollows, considerable damage was done: the water filled the lower rooms, and the inmates had to take refuge in their upper chambers.

Amongst other things, a rush of water into a pond at the head of one of the dales, caused the bank to give way. The water flowing over the edge excavated a trench in the embankment 29 ft. long, from 1 to 6 ft. wide, and from 2 to 3 ft. deep. The materials, consisting of sods, loose chalk, &c., were carried a considerable distance down the dale bottom. One sod, measuring 3 ft. by 2 ft., was carried 80 yards. A quantity of chalk gravel was collected at a spot 180 yards from the pond, but the largest mass was deposited at a distance of 295 yards, where the stream had widened to about 8 yards across. Smaller accumulations of chalk gravel continued as far as 530 yards.

The floor of the dale was covered with ice. At first the water overflowed it, but after a time excavated a passage under the ice; and standing on the ice you could see the water rushing underneath, transporting the chalk debris with it, and tearing up the turf. Nothing could more plainly show what rapid denudation of the chalk dry valleys might be carried on under glacial conditions.

Shortly after making these observations, a paper, No. 501, "Abstracts of the Proceedings of the Geological Society of London," reached me, containing a communication from Mr. Clement Reid, on the origin of dry chalk valleys, in which the writer showed that, with a frozen subsoil, the drainage system of the chalk might be entirely modified, there being no underground circulation.

* Canon Taylor. Domesday Survivals. Contemporary Review. Dec. 1886: p. 892.

The discussion which followed in the main approved of the author's views.

The sight which I witnessed in January, coupled with Mr. Reid's paper, leaves no doubt on my mind that melting snow, traversing a frozen subsoil of a few feet, might produce the running streams which so many are in search of, to account for the excavation of the Chalk valleys. This is a very different thing from saying,— 1, That at a former level of saturation, springs gushed out at the head of the dales, and formed surface streams; or 2, That the dales, in lack of surface streams, were excavated by streams subterranean, against both of which hypotheses I have always protested. At the same time we must not lose sight of the fact that similar dry valleys exist in parts of the world where we can hardly expect to find the friendly frozen subsoil, where, in fact, it never could have existed, and that these also have to be accounted for.

Whilst admitting, therefore, that glacial conditions were a *vera causa* in promoting the denudation of the Wolds, as already stated in my paper read before the society in 1879,* I still adhere to the opinion expressed in 1885,† that the main agent is the rainfall, acting not so much mechanically as chemically.

All limestones are being slowly dissolved by the carbonic acid brought in contact with them by the rainfall, and their surfaces gradually lowered. This can be proved by the fact that where a large boulder, or a tumulus of clay, acts as a covering from the rainfall, there the rock underneath is less wasted away than the surrounding parts. A trough-shaped dale offers more surface to the rain than a level piece of ground of equal width, consequently the rate of chemical erosion, in addition to mechanical, is greater in the one case than in the other. In other words, the dales are being gradually widened and deepened at the expense of the table-land, the sides preserving the angle of repose, about 30.°

I endeavoured to show, by a series of tables‡ in 1879, that the chalk area is being chemically lowered at the rate of 1 ft. in rather

* Proceedings Yorkshire Geological Society. Vol. VII. Part II.: pp. 128—140. Origin and formation of Wold Dales.

† Proceedings. Vol. IX. Part I.: p. 114. Physical Geography of East Riding.

‡ Proceedings. Vol. VII. Part II: pp. 139-140.

less than 6,000 years. Such experiments must be mainly tentative, and the increased rainfall for the last few years shows that my estimate of $27\frac{1}{2}$ inches of average rainfall was scarcely high enough. Still it may be confidently asserted that the result of the calculations is not far from the mark, and it may be inferred, that for every foot removed from the surface of the table-land, 2 ft at least are removed from the sides and bottoms of the valleys.

NOTES ON CLASSIFICATIONS OF CYCLOSTOMATOUS POLYZOA: OLD AND NEW.

BY GEORGE ROBERT VINE.

From the time of Lamouroux and Goldfuss to the present, the group of organisms which we now characterise as Bryozoa, or Polyzoa, have received marked attention from naturalists. There has been, however, many misconceptions as to the true affinities of this, with other groups,—and many misunderstandings in consequence—but at the present time Polyzoa literature is becoming rather abundant, and the misconceptions are, to a large extent, things of the past.

With regard to this preliminary paper, I may be allowed to say that my object in writing it, is to place before the student the aims and outcome of the various classifications of the Cyclostomata extant, not for any desire of contesting the conclusions of the authors referred to, but more for the purpose of keeping controversal matter out of my future papers.

The divisions of the Polyzoa now generally recognised by naturalists :—

I.—Cheilostomata.

II.—Cyclostomata ; and

III.—Ctenostomata ;

were originated by Mr. Busk in his catalogue* of the Marine Polyzoa in the British Museum, and in the monograph of the Fossil Polyzoa of the Crag.† After the publication of the latter work, two elaborate papers followed from the pen of Professor Smitt, on Scandinavian

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* Parts I. and II. † 1859.

Bryozoa,* who accepted the divisions, but not the synoptical arrangement of Busk. Professor Smitt, however, based his modified arrangement of the Cyclostomata, on apparently more solid ground than that of Mr. Busk, bnt many of his generic divisons were suggestive, rather than natural. Mr. Busk says: "Although unprepared to follow Professor Smitt in many of his conclusions, and disposed to disagree with him in many points as regards the limitation of genera and species, the Author is fully convinced that Professor Smitt's observations will mark the commencement of a new era in the study of the Polyzoa, and that they will serve, in many cases, to indicate the direction in which our attempts at their natural classification should proceed."†

In his introductory chapter,‡ Mr. Hincks says, respecting Professor Smitt's labours, that "he has aimed at a geneological classification, starting with the proposition that the variations of species follow the line of their development, and may be in a great measure explained by it. The Polyzoa . . . . as compound animals offer great facilities for the study of the laws, and causes of variation. The differentiation of the colony gives us a series of variations, running from the early and simple states, to the fully developed form, which is the parallel of the series of differences amongst species." As an example of Smitt's meaning, Mr. Hincks cites an appropriate example.|| "Thus, the British species of *Crissia* represents the evolutional stages of one and the same type, of which Smitt regards *C. geniculata*, Milne-Edwards, as the first and simplest." There is no doubt, whatever, but that Professor Smitt's classification of Recent Polyzoa rests on a thoroughness of research, as suggested by Mr. Hincks, "and the important contribution which he has made towards a natural system," it is impossible to estimate too highly, "however much we may be disposed to dissent from some of his results."§ Mr. Hincks further remarks,—1 "In his great work on the Embryology of the Polyzoa, Barrois contends that in classifying

* British Fort. Ofver Scand. Hafs. Bryoz. 1864-5.

† Catalg. Cyclostomatous Polyzoa (Busk), 1875, p. 1.

‡ British Marine Polyzoa, p. cxx., 1880. || Ibid.

§ Brit. Mar. Polyzoa, p. cxxiii. 1 Ibid.

these animals, account should be taken of all the forms in the life-series together, and sketches an arrangement suggested by the study of the larvœ (p. 250), for comparison with that of Smitt, from which it differs in some respects."

One of the real difficulties which the systematist has to encounter in dealing with Fossil forms, is shown by Mr. A. W. Waters, in his paper on the "Fossil Cyclostomatous Bryozoa, of Australia.* The author says: "The determination of the Cyclostomata presents much greater difficulties, and is much more unsatisfactory than that of the Cheilostomata, as there are fewer characters that can be used." In classifying the Tertiary Cyclostomatous Bryozoa, of Australia, Mr. Waters endeavoured to free himself, to some extent, from the modes of other authors in dealing with the group, and in doing so, he presents to the student new lines of investigation. The size of the aperture, as pointed out by Smitt, and re-worked by Mr. Waters, "seems to be fairly constant in the same species. The variation in size is not very great, ranging only from 0.03 millim. to 0.2 millim., in all species measured ; but anything greater than 0.16 millim., or less than 0.07 millim., is very exceptional," (p. 675.) One of the more useful characters in the Cyclostomata for determining specific—and perhaps even generic variation—is found in the calcareous closure,† which may be noticed in some of this Zoœcia of Recent, Tertiary, and even Cretaceous Polyzoa. "The position of these closures, together with the nature of the perforations, is a character of considerable importance," although it is neither so available nor so important as the horny operculum," of the Chilostomata (Q. J. G. Soc. Vol. xl., p. 675.)

After touching upon these purely structural features of the Cyclostomata, Mr. Waters offers many suggestions as to the arrangements of the group, and on this head he does not differ very materially from that of Mr. Busk and Mr. Hincks, except that in discussing the merits of some of the genera accepted by Reuss and others, he questions their value. These will be referred to again further on.

* Quart. Journ. Geol. Soc. Vol. xl., p. 674.

† Closure of the Cyclos. Bryozoa. Jour. Linn. Soc. Vol. xvii., p, 400.

In his last work,* Mr. Busk, in arranging the Cyclostomata, of the Challenger dredgings followed that, which he had previously adopted in his Monograph of the Crag Polyzoa, 1857, and in the British Museum Catalogue, Pt. III., 1875, "the number of species procured by H.M.S. Challenger, belonging to this sub-order, not having been sufficiently large to lead to any material change in it." In dealing with the Geological distribution of the sub-order, Mr. Busk does me the honour of quoting and accepting my opinions on two very important points. "To the sub-order Cyclostomata, belong most of the oldest Fossil Polyzoa that have been found up to this time, whilst 'as yet we have no clear evidence that Cheilostomatous types existed in Palæozoic times:' (Vine, Quart. Jour. Geol. Soc. Vol. xl., p. 332.) Although in the Mesozoic and Tertiary strata Fossil Cheilostomata are numerous. The palæontological evidence as to the antiquity of the Cyclostomata is fully confirmed and strengthened by the embryological researches that have recently been so carefully and accurately made by various authors: for instance, M. Barrois (Ann Mag. Nat. Hist., ser. 15. Vol. x., p. 391, footnote) says that the study of the structure of the larva, and of the formation of the cell coincides with palæontology in furnishing us with perfectly concordant results, which are conclusive as to the antiquity of the Cyclostomata."†

In his latest Palæontological paper, Mr. A. W. Waters‡ remarks, suggestively, as follows:—"I would propose that we should divide the Cyclostomata into two sub-divisions, namely—first, the *Parallelata;* and secondly, the *Rectangulata.* This would simplify the arrangement of the larger groups, and so far we gain by Mr. Waters' suggestion. The lesser groups, however, are left nominally the same, as arranged by Busk and Smitt, and by the Rev. Thomas Hincks.

To a large extent, Mr. Waters has been engaged in the study of species and groups of Cyclostomata, found in the Upper Tertiary Rocks of Australia, as well as the more recent forms. The evidence afforded by the study of these is necessarily limited, but in every

* Report on the Polyzoa (Challenger Rep.), Second Part Cyclostomata, 1883, p. ii.

† Ibid, pp. iii. and iv.

‡ Quart. Journ. Geol, Soc. Aug, 1887. Vol. 42 p. 337.

case where it was possible for him to do so, reference has been made to species of fossils found in the Cretaceous, and also in the Jurassic rocks, in the neighbourhood of Caen; and the celebrated Mæstricht beds, so ably illustrated by the labours of Lamouroux, Goldfuss, Haime, D'Orbigny and Hagenow. Since then, however, many of the beds of the horizons named have been reworked by Dr. Pergens and A. Meunier, and the whole of D'Orbigny's species have been critically examined by Dr. Pergens, and I have not the least doubt, but that many suggestions will be forthcoming, when he arranges his notes for publication. As it is, I can only deal with published papers, and in several of these I find certain conclusions arrived at by the author in his critical studies, which will have to be considered before a final arrangement of the Cyclostomata can be made. Thus, in their joint paper on "New Bryozoa of the Upper Cretaceous,"* (or Mæstricht Beds), the authors establish a new family, and three new genera, for the reception of a peculiar group of Polyzoa; and in other papers several of the almost obselete genera, of D'Orbigny, have been consistently revived. The new Family, CAMERAPORIDÆ, the authors place in the "Centrifuginés de D'Orbigny, division des Tubulinés," and the new Genera, are called respectively *Camerapora* (one species); *Clausacamerapora* (one species and variety); and *Curvacamerapora*, also one species.

From all this it may be gleaned that although much has been done by the authors who have succeeded Busk and Smitt, much still remains to be done, even with the proper classification of the Mesozoic Cyclostomata, let alone the Palæozoic groups, which are now being so elaborately illustrated by Mr. E. O. Ulrich, Palæontologist of one of the United States Geological Surveys.

All that I shall attempt, then in this paper, is to place before the student of our Fossil Polyzoa, the classification of the Cyclostomato adopted by the several authors already mentioned, so that he may be able to judge of their relative, or suggestive value.

The classification of the Jurassic Bryozoa, by Jules Haime,* is a very simple affair: all his species—excepting two—are placed in

* Memories de la Soc. Roy. Malacologeque de Belgique Tome xx., 1885.
† Jarassic Bryozoa, 1854.

one family, Tubuliporina, M. Edwards. Haime, however, did not endeavour to give a synoptical arrangement of his groups, and it was not until the appearance of Mr. George Busk's Monograph of the Fossil Polyzoa of the Crag,* that any really detailed notice of the fossil groups were published, and then Mr. Busk confined his notice more particularly to Recent and Tertiary Polyzoa. It may be well to remember that the Crag Monograph was "originally undertaken by the late much-lamented M. Jules Haimes, but he was unable even to commence it, before death put an end to the labours of one whose accurate knowledge and practised observation of similar fossil remains, would have enabled him to treat the present subject far more satisfactorily than it has been in my power to do."† Whether Haime, as Mr. Busk suggests, would, or would not have given to the world a better monograph of the Crag Polyzoa, is useless to speculate about; but, no doubt, Haine's familiarity with the Jurassic forms, would have helped him much in the nomenclature of species—especially so, as Mr. Busk admits that he had "formed but an imperfect idea of the difficulties attending the investigation and accurate discrimination of fossil forms," previous to his labours on the Crag species. To this we may owe some of the hesitations on the part of Mr. Busk, and in all probability he overlooked the structural peculiarities of many of the earlier fossils; and to some extent he may have misinterpreted the structural features of others. On the whole, however, the synopsis of the *Tubuliporina* of M. Edwards has been well divided by Mr. Busk; and generally speaking, his Sub-orders have been accepted by leading authorities who have made a comparative study of Fossil Polyzoa. It would be beside my purpose to refer to, or criticise the divisions of Hagenow and Reuss, because it must be admitted that their arrangements, previous to the publication of the Crag Polyzoa were very artificial, and in his later works, Reuss followed Busk in his arrangements.

In his introductory observations, Mr. Busk gives the synopsis of the Primary Divisions of the Polyzoa, as followed by him, partly

* 1859.

† Busk Advert. to crag Polyzoa.

Since found Recent Catalogue of Cyclos-Busk, p. 29, 1875.

in his two British Museum Catalogues, but the plan of the synopsis generally, we owe to Professor Allman :*—

Order I.—Phylactolemata Allman.
With two Sub-orders.
„ II.—Gymnolemata Allman.
Sub-order III.—Paludicellea (fresh water).
„ IV.—Cheilostomata, *Busk* (Marine).
„ V.—Cyclostomata, *Busk* (Marine).
„ VI.—Ctenostomata, *Busk* (Marine).

Only Sub-order V. will be dealt with in this paper, and following Mr. Busk,† I will italicise, as he has done the families and genera, which contain living species :—

I.—Articulatæ s. radicatæ		I. Crisiidæ	1. *Crisia.*
			2. *Crisidea.*
II.—Inarticulatæ s. adfixæ	(*a*) Cellulis distinctis	II. Idmoneidæ	3. *Hornera.*
			4. Terebellaria.
			5. Cricopora.
			6. Cyrtopora.
			7. *Idmonea.*
			8. *Pustulopora.*
		III. Tubuliporidæ	9. Mesenteripora.
			10. *Tubulipora.*
			11. *Alecto.*
		IV. Diastoporidæ	12. *Diastopora.*
			13. *Patinella.*
			14. *Discoporella.*
			15. *Defrancia.*
	(*b*) Cellulis indistinctis	V. Cerioporidæ	16. Stellipora.
			17. Fungella.
			18. Heteropora.
			19. Neuropora.
			20. Alveolaria.
			21. Spiropora.
			22. Heteroporella.

* Crag Polyzoa, pp. 8-9.
† Ibid, p. 91.

VI. Theonoidæ	23.	Theonoa.
	24.	Fascicularia.
	25.	Lopholepis.
	26.	Apsendesia.
VII. Frondiporidæ	27.	*Frondipora.*
	28.	Truncatula.
	29.	Distichopora.
	30.	Plethopora.

It is of no service whatever, to hide from the student the suggestion that the above grouping is anything but natural, when fossil species below the Crag are under consideration, or even certain species in the Crag. To a large extent the grouping is built up from partially facial characters, and I am not at all surprised to find Palæntologists offering suggestions, or making re-arrangements of the family grouping. The family *Cerioporidæ* is particularly obnoxious, for there is not the least affinity between the *Spiropora* of Haime, and the *Heteroporella* of Busk. The type of the family Idmoneidæ should have been, so far as I am able to judge, *Idmonea*, and not *Hornera*; then the genus *Terebellaria*, as defined by Lamouroux and D'Orbigny, would find no resting-place here. If, however, we accept the genus as defined, and in all probability limited, by Haime, *Terebellaria* is a *Diastopora* adhering to, and simulating the undulations or ramifications of the fossil organism to which it is attached. *Cricopora* and *Spiropora*, in all probability, belong to the same group, yet one genus is placed in the Idmoneidæ, and the other in the Cerioporidæ—one, the cells distinct; the other, the cells indistinct.

Professor Smitt's arrangement of the Cyclostomata,*—as already stated—is open to objections, but his grouping is by far the more natural; and it must not be forgotten that Smitt treated of recent Cyclostomata only, whereas Busk endeavoured to grapple with recent and fossil species in one synopsis. Smitt arranged the Cyclostomata as follows:—

Tribe, Infundibulata, Gervais.
Order, Cyclostomata, Busk.

* Krit. Fortneck. Ofver Skandinaviens Hafs Bryozoer, 1864-65.

= Centrifuginea, D'Orbigny.
Sub-order, Radicellata, D'Orbigny.
= Articulata, Busk.

I.—Family Crisia. 1. Crisia, Lamx.

Sub-order, Incrustatatæ, D'Orbigny.
= Inarticulata, Busk.
I. Tubulinea, D'Orbigny.

II.—Family Diastoporidæ. 2. Diastopora, Lamx.
3. Mesenteripora, M. Edw.

III.—Family Tubuliporidæ.
Sub-genus—4. Idmonea, Lamx.
Sub-genus—5. Phalangella, Gray.
Sub-genus—6. Proboscina, Aud.

IV.—Family Horneridæ. 7. Hornera, Lamx.

V.—Family Lichenoporidæ. 8. Discoporella, Gray.

II. Fasciculinea, D'Orbigny.

VI.—Family Frondiporidæ. 9. Frondipora, Blainville.

VII.—Family Corymboporidæ. 10. Corymbopora, Mich.
11. Defrancia, Bronn.

As already stated, Mr. Busk, in the third part of the British Museum Catalogue, agreed with Professor Smitt in his critical suggestions, but he failed to modify, to any great extent, the synoptical arrangement of the Cyclostomata, as adopted for the Crag Monograph. Very wisely, the Family of the Diastoporidæ is broken up, and limited to two Genera—*Diastopora* and *Mesenteripora*—and another family founded for the reception of a peculiar group of Polyzoa, which occur both Recent and Fossil. The name of the typical genus, *Discoporella,* is the type of the Family Discoporellidæ, and the included genera are—

Discoporella, Gray.
Radiopora, D'Orbigny.
Domopora, D'Orbigny ; and
Defrancia, D'Orbigny.

And the Frondiporidæ of the Crag, is changed to the Fasciculinæ of the British Museum Catalogue. As a matter of course, the Families

* 1875.

Cerioporidæ and Theonoidæ are done away with, as no species belonging to these Fossil Groups are known to exist.

In the introduction* to the British Marine Polyzoa, Mr. Hincks modifies the arrangement of Mr. Busk, but on account of the limited range of the British region, some few alterations in the generic divisions had to be made when dealing with the Cyclostomata of Foreign regions. For the British Marine Polyzoa, only four families were adopted:—

I.—Crisidæ.	III.—Horneridæ ; and
II.—Tubuliporidæ.	IV.—Lichenoporidæ.

In the Catalogue of Marine Polyzoa of Victoria,† Mr. P. H. MacGillivray, however, accepts Mr. Busk's family arrangements, slightly altered, but he adds several new Genera as follows:— ‡

Family	I.—Crisidæ.	Crisia, Lamx.
,,	II.—Idmoneidæ.	Idmonea, Lamx.
		Hornera, Lamx.
,,	III.—Tubuliporidæ.	Tubulipora, Lamx.
		Stomatopora, Bronn.
		Diastopora, Johnston.
		Liripora, MacGillivray.
		Entalophora, Lamx.
,.	IV.—Discoporellidæ.	Lichenopora, Defrance.
		Densipora, MacGillivray.
		Favosipora, MacGillivray.
		Flosculipora, MacGillivray.
,,	V.—Frondiporidæ.	Fasciculipora, D'Orbigny.

It will be noticed in common with other workers, that Mr. MacGillivray uses the Generic term *Entalophora*, instead of *Pastulopora* (Busk, Brit. Mus. Cat., pt. III.) The reason which Mr. Hincks gives for reinstating the first generic name, is, on the whole, perfectly agreeable, but out of common fairness, Mr. Busk's reason for rejecting the term will be given further on. "A question arises," says Mr.

* London: John Van Voorst, 1880, p. cxxxix.

† Transactions (?) Roy. Soc. Vict., 1886.)

‡ New Genera in Italics.

Hincks,* "as to the name of this Genus (Entalophora), . . . Busk seems to admit that in strict propriety, Lamouroux's designation is entitled to precedence ; but he thinks that, to restore it under the circumstances, would savour of pedantry (Crag Polyzoa, p 107). I confess it seems to me that the fewer departures from the established rule the better. The accidental prevalence of a much later name, does not appear to be a reason for retaining it. On the contrary, it may be a salutary vindication of the authority of the law to reject it after such usurpation. The best cure for the disorders of our nomenclature seems to be a vigorous application of the principles which are generally accepted for its government. *Lamouroux's*† *genus is characterised in a well known work ; and both diagnosis and figure are sufficient for identification :* its claim seems to be complete."

If the acceptance or rejection of a generic term was only a question of priority, as Mr. Hincks seems to think, then, the matter would be very easily settled, as the term *Entalophora* is by far the oldest one. But in this case we have two eminent authorities contending, not merely about a name, but really about a structural peculiarity which leads Mr. Busk to question the identity of Lamouroux's species as of sufficient authority to justify the acceptance of the typical form to which Lamouroux gave the name Entalophora. In his last work, Mr. Busk discussed the whole question under the generic term, Pustulopora.‡ The author says, "Although most recent writers, including such high authorities as Professor Smitt and Mr. Hincks, have adopted the name *Entalophora*, for the genus here intended, I am inclined, with the greatest deference, to prefer M. de Blainville's and M. Milne-Edwards' name, for the reason that the species named *Entalophora*, by Lamouroux, appears to me to differ in at least one most important respect, it may be said from all the other known Cyclostomata, and most certainly from all with which I am acquainted, either recent or fossil, viz., in the *appendages*, as he terms them, *being trumpet shaped, or gradually increasing in diameter as they increase in length.*§ Whether this arises from an

* Brit. Mar. Polyzoa, Vol. i., p. 455.

† Italics Mine.

‡ Challenger Report, Pt. ii., Cyclostomata, &c., p. 18.

§ Italics mine, in all instances, in the body of the quotations.

error of observation on the part of Lamouroux, or of his draughtsman, or is the true condition, may, perhaps, admit of doubt: with the exception of M. Michelin (Iconog. Pl. lvi., fig. 4), whose figure very strongly resembles that of Lamouroux, no one seems to have recorded any other form with trumpet-shaped tubes; and as even his figure does not represent them as having that form, I am much inclined to assume that Lamouroux's specimen is unique in that respect, and if correctly figured and described, that it must, on that account alone, be referred to a distinct generic type from all other known Pustuloporidæ, and in fact, as above observed, from all other Cyclostomata. (May it not be a coralline?) On the other hand, M. de Blainville's definition of *Pustulopora*, as distinguished from Lamouroux's *Entalophora*, is so clear and precise, and his genus has met with the acceptance of M. Milne-Edwards, Hagenow, Reuss, and numerous others, and in fact may be said, until quite recently, to have been in full possession of the field, that I feel no hesitation in retaining it for *all forms with cylindrical tubes of the same diameter throughout;* and relegating those forms, if there really be any, with trumpet-shaped tubes, to at least a distinct genus."

If we revert now to the Crag Polyzoa, p. 107, we shall find that the opinion now so forcibly put by Mr. Busk (Challenger Rep., pt. ii., as above), was only hesitatingly adopted in the former work. It was not then wholly a question of structure; but, as Mr. Hincks says suggestively, a question of diffidence as to priority, or clearer definition. Mr. Busk says: "I have adopted Blainville's name for this genus (Genus 3. Pustulopora), more for the reason that it has come into general acceptation, especially since its accurate definition by Milne-Edwards, than because I am satisfied it should have precedence of *Entalophora*, a term under which it appears *quite clear that Lamouroux had intended to include similar forms.* The prior appellation, however, having fallen into abeyance, except by M. D'Orbigny, whose genus *Entalophora*, moreover, is not confined to Cyclostomatous forms only, it seemed unadvisable, merely for the sake of somewhat pedantic propriety here to revive it."

Neither of these authors has drawn attention to the fact that Jules Haime, in his Jurassic Bryozoa, only places one species in the

genus Entalophora, while he uses the term *Spiropora* for several species which would, under the restored nomenclature of Hincks, be placed under *Entalophora*.

In their joint memoir on the "Bryozoa of Faxæ Limestone,"* Denmark, the authors, Drs. Pergens and A. Meunier have formulated an entirely new arrangement of the Cyclostomata, so as to meet the necessities of grouping species having certain structural affinities, which, though not apparent in the more recent forms, are very abundant in the whole of the Mesozoic Rocks. So far the authors are to be commended, but unless their grouping is studied in connection with the species grooped together, the student will miss many of the finer points brought out by the authors in the arrangement. It is here, and in the Palæozoic Rocks, that we begin to lose the peculiarities on which the classsification of the more recent Cyclostomata are based; and even in his own labours on the Upper Tertiary species of Australia, presently to be referred to, Mr. Waters has felt the necessity of re-introducing obsolete genera. The necessity is increased whenever we deal with the Polyzoa critically, as we go backward in time. Dr. Pergens and A. Meunier, arranges the Cyclostomata as follows :—

BRYOZOA, CYCLOSTOMATA.

Family I.—Stomatoporidæ.	Stomatopora, Bronn.
,, II.—Diastoporidæ.	Diastopora, Lamx.
,, III.—Entalophoridæ	Entalophora, Lamx.
	Pustulopora, Blainv.
	Bidiastopora, D'Orbigny.
	Escharites, Hagenow.
	Spiropora, Lamx.
	Sparsicavea, D'Orbigny.
,, IV.—Idmoneidæ.	Idmonea, Lamx.
	Reptotubigera, D'Orbigny.
	Hornera, Lamx.
	Filisparsa, D'Orbigny.
,, V.—Tubigeridæ.	Bisidmonea, D'Orbigny.

* La Faunæ des Bryozoaires Garumniens de Faxæ. Annals de la Soc. Roy. Malacol de Belgeque. Tome xxi., 1886.

	Tuberculipora, New genus.
,, VI.—Cameraporidæ, N. Fam.	Camerapora ,,
	Clausacamerapora ,,
	Curvacamerapora ,,
,, VII.—Fasciporidæ.	Fungella.
	Supercytis, D'Orbigny.
,, VIII.—Fasciculiporidæ.	Cyrtopora.
	Truncatula.
,, IX.—Heteroporidæ.	Heteropora.
,, X —Lichenoporidæ.	Lichenopora.
	Discoporella.
	Radiopora.

I have arranged the family grouping with its included genera as above, only to the extent of the published details of these respected authors. It is fair to state, however, that Messrs. Pergens & D. Meunier are still carrying on their investigations, and how far they may modify, or restrict their grouping in future labours, I am not in a position to judge. The authors are in earnest with their work, and I believe we shall have some good papers from them on Faxæ Limestone, and other forms.

In his latest Palæontological Paper* on Tertiary Cyclostomata from New Zealand, Mr. A W. Waters has given us the result of his more matured views respecting the divisions of this Sub-order, and we may regard this as a supplement to his previous paper on the Cyclostomata from Australia.† I know full well that the attention of Mr. Waters has been directed to the grouping of the Cyclostomata for many years, and we may, therefore, regard this paper as the outcome of many years of thought. As Mr. Waters says (Op. c. p. 337), "The second part of Mr. Busk's Report is a great disappointment . . . . as only thirty-three species are recorded, and these are for the most part well known and common. In fact, the results of this great expedition do not seem, so far as the Cyclostomata are concerned, to exceed what I presume a specialist might, after a storm,

* Quart. Jour. Geol. Soc., Aug. 1887, pp. 337-350.

† Q. J. G. Soc., Vol. 40, 1884, pp. 674-696.

collect in a few morning walks in the neighbourhood of Sidney Harbour."

With regard to the classification of the Cyclostomata, Mr. Waters says (p. 337): "I would propose that we should divide the Cyclostomata into two sub-divisions, namely—first, the PARALLELATA, or those in which the surface of the Zoarium is, to a considerable extent, formed of the lateral walls of the Zoœcia;" TYPES—*Crisia*, *Entalophora*, *Diastopora* and *Tubulipora*: "And secondly, the RECTANGULATA, or those in which the Zoœcia or cancelli open for the most part at right angles to the axis or surface of the Zoarium or sub-colony."—Types, *Heteropora*, *Lichenopora*, *&c.*

There are several structural peculiarities of Cyclostomatous species pointed out by Mr. Waters in this important paper, especially "rays" or "hair-like teeth" in the Zoœcia, and the closure of the tubes, as already referred to. In all our future Palæontological researches it may be well to consider the minutæ referred to, and others may be present, though overlooked by authors. I have already pointed out and described* a very peculiar mode of "closure" in a species of *Entalophora* from the Neocomian Clay of Lincolnshire. The arrangement of the Zoœcia, the punctures of the surface, and the closures in the throat of the tubes, are similar to the figured example of *Entalophora Wanganuiensis* Waters.† Other Mesozoic examples may be forthcoming, if a careful study of the Zoœcia is made.

It will be unwise to anticipate the future work of Mr. Waters on this Sub-order, but it may be well to direct attention to the already tabulated lists of species described, and also the order in which the genera are arranged by him.

I.—Parallelata, Waters.	Idmonea.
	Entalophora.
	Cinctipora.
	Hornera.
	Stomatopora.
	Diastopora.

* Notes on a species of Entalophora, from the Neocomian Clay of Lincolnshire. Ann. Mag., Wat. History, Jan. 1887.

† Q. J. G. S., Aug. 1887, p. 340, pl. xviii., f. 1.

	Tubulipora.
	Fascicularia.
	Supercytis.
II.—Rectangulata, Waters.	Lichenopora.
	Reptocavea.
	Heteropora.
	Crisina.
	Crassohornera.

As the present papers will form the beginning of a series on Jurassic Polyzoa—both British and Foreign—I can only feebly indicate the line of inquiry that I shall occcupy in my descriptions. In the first place it may be well to notice, that the only Jurassic Monograph which we have for reference is that of Haime, which was published in the Memoirs of the Geological Society of France in 1854. In this work the author described Caen and Ranville examples as well as British, and in many cases the British examples fell under the head of a type described from a foreign source. There was no objection to this, but it frequently happens that the British example differs in some few particulars—which will be referred to in the course of descriptions—and these minute differences are often very perplexing to the young student. Then again I have not been able to trace the resting-place of the British type specimens of Haime Many of them were supplied to him from private cabinets, but I am unable to say whether the whole, or any part of them were placed in any English museum. In the second place, there was no public collection of the Caen and Ranville fossils to refer to until recently. For some time past I have been collating a fine series of Caen Polyzoa for the purpose of description, which belongs to the Northampton Museum; and as much as possible I shall refer to these specimens in the course of my descriptions. Then there is a fine series of British examples in the cases of the School of Mines, and some in the British Museum. Recently, however, I have been, through the kindness of Dr. Pergens, supplied with a really good series of Mesozoic Polyzoa from various foreign horizons. and these bear the original names given to them by Lamouroux, Goldfuss, Michelin, D'Orbigny,

Hagenow, and Haime, so that I shall have now—which I did not at one time have—available material for the purpose of instituting comparisons between the British and the Foreign species. After Haime Professor Brauns* able paper on Jurassic Bryozoa found in the neighbourhood of Metz, is a valuable addition to Jurassic Polyzoa literature. Then four papers by myself—1, Notes on the Family Diastoporidæ. Quart. Jour. Geol. Soc., Aug. 1881, pp 381-390; 2, Brit. Assoc. Report on Fossil Polyzoa, Jurassic species, British Area only. Brit. Assoc. Rep., 1882-3. 3, Notes on Polyzoa found in the Boring at Richmond. Quar. Jour. Geol. Soc., Nov. 1884. 4, Jurassic Polyzoa in the neighbourhood of Northampton; Journ. of the Northampton Nat. Hist. Soc., 1886. There is also a paper on Jurassic species, by F. D. Longe, F.G.S., on the Relation of the Escharoid Forms of Oolitic Polyzoa, &c. Geo. Mag., 1881. Besides these there are scattered remarks in species found in papers by authors when describing Polyzoa from other horizons which will be referred to in passing

I have already indicated the leading ideas of Mr. A. W. Waters, in his several papers on Australian Tertiary Bryozoa; and in my future studies of this interesting group of fossils, I shall note—if there be any to note—peculiarities of structure indicated, viz., the "closure," puncturing of the cells, growth, and arrangement of the cells in the colony.

I shall be glad of any help that can be given to me by collections in this labour of love; and I hope that much of the material that is hidden away in cabinets will be brought to light, and made available to the students of British Jurassic Polyzoa.

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* Bryozeen des mittleren Jura der Gergend von Metz, in Zeitscher, D. Deutsch. Ges. Bd. xxxi., 1879.

ON SOME SECTIONS EXPOSED IN MAKING THE SKIPTON AND ILKLEY RAILWAY. BY S. A. ADAMSON, F.G.S.

It is obviously necessary that when a new railway is in process of construction in any locality, that the geologists of the district should be on the alert to increase their practical knowledge by visiting, and carefully examining the various sections revealed in the progress of the work. Such an opportunity was presented by the new line intended to traverse the district between Skipton and Ilkley. Permission was readily granted by Mr. C. S. Wilson, C.E., engineer to the line, to inspect it; this was done, and, in addition to this privilege, the route was expanded, so that the geology of South Craven, with the complex disturbances of the strata, was studied. Commencing at the Skipton end of the line, it may be well to give a few details of the railway itself. The new line from Skipton to Ilkley joins the Midland line a little west of Skipton Station, and on the Carlton side, thence passing over the Eller Beck by an arch, it skirts the base of Skipton Moor. This is to save going through the town, and to obtain increased length, the gradients being 1 in 85, and 1 in 90, up to the tunnel. The work is very heavy for 2½ miles, there being eighteen bridges besides the tunnel; in addition the cuttings, as will be shown shortly, being cut through stiff boulder clay or till, have been most difficult work. This deposit of till is not only stiff, dense, and tough in a remarkable degree, but contains countless blocks of stone, scattered up and down without regard to size or weight. Some of these blocks are rounded, others have their angles just blunted, and many are ice scratched or polished. The first cutting, about 120 yards long, has a maximum depth of 6 feet; in the second about 750 yards long, the greatest depth is 41 feet, both are cut through very stiff boulder clay. Then succeed Cuttings Nos. 3 and 4, with embankments between; No. 3, about 90 yards in length, and about 2 feet deep; No. 4, about 200 yards in length, with a greatest depth of 16 feet also through boulder clay. After passing along a lofty embankment,

we arrive at Cutting No. 5, which forms the entrance to the tunnel. It is about 120 yards long, and at the mouth of the tunnel 60 feet in depth. This is likewise through boulder clay. Along the sides of the cutting were huge heaps of the boulders which had been extracted ; these were carefully examined, and appeared to be nearly all local gritstones or mountain limestone. This boulder clay rests directly upon the limestone, and a section was seen showing the junction, the limestone dipping, at an angle of about 55 degrees. Where the boulder clay had been entirely removed, the weathered surface of the limestone was exposed, and this showed well the corrugations arising from denudation so familiar upon limestone surfaces. When making this cutting a pot-hole was discovered in the underlying limestone, full of peat and silt, it was excavated and drained for a depth of 6 feet, and then filled up with stone. The tunnel will, when completed, be 220 yards in length, and lies about due north and south. The strata met with thus far in excavating the tunnel are boulder clay and limestone, the former interbedded with gravel and silt, and again limestone, through which they were then driving. From the top of the tunnel (which runs under the western spur of Haw Bank Quarry) a magnificent view was obtained, right in front being Embsay Crag, with the pretty village of Embsay nestling beneath; sweeping eastwards are Halton Heights, with the thickly wooded hamlet of Halton East; further on Simon's Fell and Beamsley Beacon. Turning to the south-east could be seen one of the long ridges of Skipton Moor; on the opposite side of the Skibeden Valley, westwards, the horizon could be seen bounded by Pendle Hill, and Longridge Fell in Lancashire ; working round northwards are the gritstone peaks of Flasby Fells and Rylstone Fell, till the circuit was completed by Crookrise and Deer Gallows on Embsay Moor, one of those majestic stretches of landscape which enables the geologist to grasp the physical features around him. The other entrance to the tunnel, which is approached by cutting No. 5a, is a little over 600 yards in length, and greatest depth 60 feet (at the mouth of the tunnel). The lowermost bed was again the stiff, blue, stony till, overlaid by fine loamy sand showing bedding planes, some being cross-bedded, this was capped by another clay,

the latter probably re-arranged glacial beds. This cutting occasioned considerable outlay from the cost of draining and strengthening the slopes with dry rubble counterposts. The railway was now left for a short time, the cutting being ascended, and a detour made by a long subterranean passage into the famous Haw Bank Quarry (commonly called Skipton Rock). This quarry is worked by the Leeds and Liverpool Canal Company, and the limestone which is used for iron smelting, road metal, &c , is taken along a tramway (worked by steel wire ropes from the engine house at Embsay) down to a branch of the canal behind Skipton Castle, and there tipped into boats. The section is of interest to the geologist, not only from its stupendous size, but also that it reveals so clearly the stratification on the north side of the great Skipton anticlinal. The height of the quarry is 255 feet, and the strata, which are composed of dark grey and blackish limestone, with thin beds of black shale intervening, dip at the western end of the quarry from 40 to 55 degrees W.N.W. Proceeding eastwards, the dip increases until it reaches 80 degrees, that is nearly vertical. At the south side of the anticlinal ridge of Haw Bank, was seen the Skibeden Quarry. Here beds of dark grey, blackish compact limestone were observed precisely similar to those of Haw Bank. It will be remembered that at Haw Bank, just at the other side of the ridge, the beds had a rapid dip to W.N.W. At Skibeden the exposed limestone dipped sharply to the S.E., or just in the contrary direction. In South Craven, the anticlinals bring up the limestones between the shales and grits of the Yoredale and millstone grit series. The synclinals on each side of the valley forming the hills, are composed of the latter rocks. The fact of the anticlinals usually forming valleys, whilst synclinals form high ground between them, seems at first sight somewhat paradoxical; but as Mr. Topley and others have pointed out the synclinals being compressed and compact, are apt to resist denudation ; whilst anticlinals from their being broken up, or fissured at the summit, would be readily acted upon by atmospheric agencies. Thus says Professor Geikie, "That which in geological structure is a depression, has by denudation become a great mountain, while what was an elevation has been turned into a valley." It is probable that

the period of these disturbances was between the end of the Carboniferous, and the beginning of the Permian formation, during the period of denudation existing between the two eras. The railway was now resumed, it had been carried from Cutting No. 5a, upon a low embankment nearly a mile in length. In one part a deposit of peat had been met with, and in other parts soft silty clay, which caused the foundations of four bridges near Embsay to be very costly, it being necessary to sheet pile, and excavate to a considerable depth. Embsay Station will be on the side of this embankment, immediately below the village of that name. For about 900 yards further, the railway runs in a shallow cutting, and along another embankment, till we reach Cutting No. 6, a little over 1,000 yards in length, with a maximum depth of 31 feet. This was cut through gravels, sands, and clays at each end; but in the centre, under Holywell Lane, arose a boss of limestone. This is the summit of the line; the level of the rails at this part is 513 feet above the sea, the fall to Skipton Station being 183 feet, and to Ilkley 201 feet. A little to the north of this is a small quarry of limestone, which presented a contorted appearance. A shallow embankment, about 700 yards in length follows, with boggy land on either side. Here a peat deposit, about 14 feet in thickness, had been met with, and another engineering difficulty had to be faced. Branches of trees have been spread on the ground, and interlaced, to prevent, if possible, the embankment breaking through the harder crust of warp and earth overlying the peat. Cutting No. 7 was next traversed about 1,100 yards in length, and a greatest depth of 14 feet. It is mostly cut through clays, gravel, and sand. At Draughton Bottom another detour from the railway was made, and close to the line on the south, a new quarry of limestone has been opened, which has proved to be a good stone for building. The hill was then ascended to view the section behind the Matchless Inn at Draughton—a name which has also a special fitness for the section. In this quarry, within a distance of some 30 yards, the beds of limestone bend without breaking into two sharp anticlinals, with corresponding synclinals, that is, roughly speaking, in the shape of an inverted W. To give a better idea of the extent of this con-

tortion, it may be stated that these beds dip respectively, beginning at the left or north side of the section, 60 degrees N.W., 52 degrees S.E., 75 degrees N.W., 10 degrees S.E. The rock thus bent is the mountain limestone, very similar in composition to the Skipton Rock already named. There are three great leading causes to account for this splendid example of contortion; firstly, immense lateral pressure; secondly, the slow and very gradual operation of the same; and thirdly, the pressure during crumpling of a vast thickness of overlying strata, since removed by denudation. On the north side of the quarry was observed a good example of "slickensides;" it was finely polished, and the groovings or striæ were remarkably distinct. A little way from this section, a hurried glance was taken at the Wheelam Rock Quarry, where there is another fine example of contorted limestone beds. The limestone has a dip of 65 degrees S.S.E., but inside the quarry the beds tilt up again, and form a striking example of a synclinal or trough. The railway was again resumed, and an embankment traversed, about 1,000 yards in length, under which was found in foundations for bridges and culverts, hard black and brown shales. A short walk brought the party to a point where the line passes through the lower side of a quarry belonging to the Duke of Devonshire, and worked for limestone; this is used for road metal, and also burnt for agricultural purposes. This quarry, known as the "Hambleton Rock," is famous for evidence of the great geological disturbance already referred to. On the eastern side of the quarry could be seen the various beds of shale and limestone (which were very distinctly laminated) dipping to the N.W., at an angle of about 40 degrees, then turning at a sharp angle and becoming vertical. The beds were seen to continue thus vertical to the west side of the quarry, and indeed, near the summit of the section in one spot, even to turn over a little upon themselves, thus actually reversing the order of deposition. The dark coloured limestone was traversed by innumerable veins of calcite, which were approximately transverse to the surface of the beds. An embankment was passed over about a quarter of a mile in length, on which will be situated the Bolton Bridge Station, distant from the Devonshire Arms about three quarters of a mile. The Cutting No. 9 was

then entered about 400 yards in length. The greatest depth is 31 feet, and here the Yoredale Rocks are exposed. They consist largely of black shales, but contain also beds of earthy and sandy limestones and sandstones. In this cutting the beds observed were black shales dipping to the S E., at an angle of 25 degrees, and a little further on were beds of black limestone, which had been stained by decomposed organic matter, for, on breaking pieces off, a peculiar fetid smell was felt, somewhat resembling that from petroleum. The dip soon caused these strata to disappear, their place being taken by a drab-coloured, fine-grained gritstone, containing specks of mica. This was evidently a valuable stone, as it had been used for bridges, &c. We emerged upon an embankment about 350 yards in length, and from this point excellent views were obtained. Another cutting, about 300 yards long follows, not yet commenced. We now arrived at the deep, well-wooded ravine of Lob Gill, cut through the Yoredale shales by the action of a small rivulet. Here and there the shales were exposed, weathering into their original state of clayey mud. The ravine will eventually be crossed by a viaduct of five arches, at a height of 70 feet above the bed of the stream. The Cutting No. 10a was now traversed about 300 yards in length, with a maximum depth of 26 feet. The black shales were extremely bituminous. Another short embankment, about 200 yards in length, was then crossed to Cutting No. 11, about 250 yards in length, with a maximum depth of 17 feet. For about 70 yards at the Skipton end of the cutting a yellow clay was noted filling up a depression in the strata. Then the gritstones re-appeared, the latter becoming as we passed more shattered in their character, and containing concretions or nodules largely charged with iron. When broken these nodules displayed a number of concentric coats. In this cutting, also, nearer the Ilkley end, the sandstone was observed interbedded with shales, the former in one great example stretching like a tongue into the latter. Crossing another embankment, a little over 300 yards in length, we entered Cutting No. 12, about 530 yards long, with a maximum depth of 10 feet. This was cut through a yellow stony clay, but no large boulders were seen. An embankment, nearly 600 yards in length, had now to be traversed to reach Cutting

No. 13, which was entirely cut through boulder clay. It had a length of 300 yards, and its greatest depth was 22 feet. Some large boulders of encrinital limestone with ice scratches, had been taken out of this clay; others of gritstone, some yellowish, some various shades of a red colour. An embankment, some 500 yards in length, brought the party to the point where the railway crosses the main street of Addingham by a bridge of 52 feet span. We now went a short distance into a cutting, which will be eventually 1,300 yards long, to note the boulder clay through which it is cut. It is of a dual character, the upper being a yellow clay, containing principally blocks of local gritstone; the lower division a stiff dark blue tenacious till, containing a quantity of rounded and subangular blocks of limestone and sandstone, many of the former ice scratched. The blocks of limestone were observed to be much more numerous in the lower division than in the overlying yellow clay. The few remaining cuttings in the Ilkley direction are also through similar clays, some showing the junction in a marked manner, but they do not call for any detailed notice.

NOTES ON FLINT-FLAKE IMPLEMENTS FOUND IN THE ISLE OF MAN.

BY JAMES E. BEDFORD.

About a year ago the writer had an opportunity to examine some sections of gravel and sand on the hillside opposite to Peel Castle. The material was much cross-bedded, and it was difficult to determine whether it was a raised sea-beach or an old river-terrace. The situation of the beds, and their elevation above sea-level, proves them to be old. They are at different elevations on the hillside, and within a few yards of the present sea margin, and about the same distance from the estuary of the stream or river running into the Harbour of Peel.

The rock forming the base is clay-slate of Lower Silurian or Cambrian age, dipping at a high angle. Lying upon this rock is a bed of gravel three or four feet thick, then a layer of sandy loam, and upon this about 10 or 12 inches of surface soil with vegetable

remains. No shells were found in the gravel, or their origin might easily have been determined. The height above the sea-level of the different deposits varies from 50 to 100 feet more or less. The sandy loam appears to be a rain-wash accumulation with vegetable matter; also the darker coloured surface soil with roots of heather, etc.

Raised sea-beaches are common on the island, and as these beds, though of great interest, do not form the subject of this article, we pass on to the beds overlying them, and give a description of the flint weapons found therein. The beds lying upon the gravel contain great numbers of flint flake implements, consisting of knives, scrapers, spear-points, arrow-tips, and pointed instruments for various purposes, such as piercing skins, bone, horn, etc. Cores and waste flakes were found along with the finished tools. The greater number were found at different depths in the surface soil, from 3 inches to 12 inches down; a much smaller number were got from the underlying bed of sandy loam, and these had a much older appearance; the flint had become white and opaque in its substance and an ocherous deposit had formed on the surface. The depth at which the latter were found varied from 18 inches to 2 feet.

The flints have been classified as follows :—

200 Flint Tools and Weapons.
181 Broken Implements and Flakes which had been rejected, but all showing design.
15 Nuclei or Cores.
66 Sundry Chips.
a total of 462.

Not having sufficient time to fully examine the gravel beds, I was unable to determine whether worked flints occur embedded therein. All the remains enumerated above were found in the beds at a lower level. The flints found are all of the same type of manufacture (although they must differ considerably in age), and from the fact of cores being found along with them they were probably made on the spot. The situation of the hill leads one to believe it to have been long frequented by man—it rises to a considerable elevation directly from the sea, and forms a good point for observation over sea and land, and commands the rocky island on which Peel Castle is built.

The writer was unable to determine the source of the flint nodules. They are ordinary grey flint from the chalk, but as no chalk strata occur on the island, it is difficult to say where they come from, unless they exist in deposits of boulder clay, drift or gravel. They would, in this case, be found washed out on the beach. The nearest point at which they could be obtained from the chalk *in situ* is the Irish coast, no more recent rock formation than carboniferous limestone existing in the Isle of Man. A close examination of the flint cores finally settles one point of the question, they were not got from the chalk *in situ*, and imported into the island. Most of the cores show a portion of the original outer surface of the nodule, and in all cases it is waterworn, and weathered to a considerable depth from the surface. Minute cracks or fractures are seen, caused by concussion in rolling to and fro, and striking one against another when beaten by the surf on the sea-beach. If the flint had been procured direct by mining in the chalk, the nodules would have presented quite a different appearance—the peculiar shapes of flint nodules recently obtained from the chalk being well known. Many of the implements are good specimens of early flint-flaking—some of the pointed instruments having no doubt required very careful manipulation to produce them, they are so small and delicate.

Taking the collection as a whole, one is struck with the rude and primitive type of the weapons—they are simple flake tools, and do not show any signs of snipping into shape after the flake was struck off—not a single specimen of a barbed arrow-head was found, nor yet showing any attempt at grinding into shape.

The general type of flake will be recognised on referring to "Ancient Stone Implements of Great Britain," by Mr. John Evans. The figures 200, 233, 395, and 397 are average examples, but the edges are untrimmed.

YORKSHIRE PETROLOGY. BY THOMAS TATE, F.G S.

Introduction.

The Igneous Rocks of Yorkshire are restricted within an area bordering on the north-west and northern boundaries of the county. Volcanic rocks, both contemporaneous and intrusive, have here representatives whose ages may be fairly well determined. If, as Clifton Ward has suggested, the volcanic series of the Lake District had a sub-aerial origin, at the same time as the Landeilo Flags were accumulating in the Welsh seas, this "marks time" for the contemporaneous Volcanic Rocks extending from Ribblesdale to Teesdale, as well as for the Borrowdale Group of the Lake District, of which indeed these form a part, the easterly and south-easterly fringe.

The Erupted Rocks of Yorkshire belong to two younger, but widely separated epochs. A varied series of trap-dykes cuts through the contemporaneous Volcanic Rocks just named, all along the line; behaving transgressively also towards the remaining Ordovician and and Silurian Groups wherever present, but never intruding into beds of Carboniferous age. In one instance where we find the unaltered scar-limestone wrapping unconformably around the denuded apex of a protruding dyke, the area of contact presents some points of interest, as we hope to show. Clearly, these dykes are of Old Red-sandstone age, and, like the Volcanic Rocks of the Borrowdale series, were erupted during a period of elevation.

The youngest Intrusive Rocks, the great Cleveland Dyke, stretching along the northern limit of the county, we shall see reason for assigning in like manner to a period of elevation, in all likelihood of Middle Eocene age.

Mica-trap, like felstone, trachyte or basalt, is a term convenient for the grouping of rocks in field work, to which indeed its vague character lends itself; hence the nomenclature of the groups has, until recently, been wanting in precision. Rocks of widely different mineral constitution have been included under this head, indeed it is no uncommon experience to find specimens in museums, or slides for

the microscope, owning two, three, or even four descriptive titles in succession, indicating the opinion of the describer for the time being. Of these, kersanton, kersantite, minette, and mica-syenite may claim brief notice. "The first described Kersanton of Brest (Riviere 1844) and the Kersantite of the Marklode Vosges (Delesse 1851) are practically indistinguishable, though Delesse employed the latter term for Hornblende-mica-diorite, and the former for Mica-diorite; while Rosenbusch (1877) restricted Kersanton to Mica-Augite-diorite."* Rutley (Study of Rocks, p. 239, 1877), regards the presence of more or less hornblende as marking off Kersantite from Kersanton, but later he abandoned the latter term altogether (Proc. Geo. Ass. VII. p. 114). Minette (Voltz 1828) is applied to a finely grained intimate mixture of orthoclase and hornblende, enclosing abundant scales of mica. These rocks pass frequently into the felsite series. Bonney (1884), &c. type, suggesting Minette felsite and Minette trachyte for the hemicrystalline and glassy forms respectively. The Minettes he regards as a small outlying group from the Syenites, an extreme form of the Mica-syenites; and the Kersantites as extreme forms of the Mica-diorites. However, not seldom is the determination of the felspar—orthoclase or plagioclase—in this group of rocks extremely difficult; while occasionally in the series of Mica-traps we are having under consideration, we shall meet with examples in which both are found associated, just as Rutley and Clifton Ward have done in the allied Mica-traps of the Lake District. The difficulty of determining in some cases the felspar species, in others the predominating felspar, has led to the adoption of the comprehensive term Lamprophyre (Gürnbel 1879), in the sense recommended by Rosenbusch (1886, who used it as a convenient designation for the Mica-diorites, and the Mica-syenites with their intermediate members whether wholly or only partially crystalline.

* M S., Geo. Lab. Museum, Royal School of Mines, S. Kensington.

I would gratefully express my indebtedness to the Science Department, and especially to those responsible for the Geological Laboratory, for the facilities for research, without which this series of papers could not have been attempted.—T. T.

I.—The Lamprophyres.

(1) In the picturesque dales lying at the foot of Ingleborough, the Ordovician system is represented by its middle and upper series—the Borrowdale and the Coniston Limestone Groups—in nearly vertical position, with the mountain limestone resting upon their upturned edges. After the Chapel-le-Dale Beck has flowed past the last green slate quarry, on its way to that charming health resort, Ingleton, it cuts through a felspathic ash-bed, the latest member of the volcanic series. The physical transition is indicated by the presence, above and below this bed, of sedimentary deposits consisting of yellow micaceous sandstones and shales, the latter gradually acquiring a calcareous character, until finally capped by the fossiliferous Coniston Limestone, and its superimposed calcareous shales extending as far as the northern fork of the Craven fault. Jutting out boldly into the stream, from the receding contorted shales forming its left bank, we meet with a rock of some historical interest, as it was first described by Philips in 1832, and is the only one of our series that he deemed worthy of special notice. "The composition of the stone," he says, "is remarkable and uncommon. It is a fine-grained crystallised compound of red felspar, light-coloured hornblende and mica, occasionally holding large masses of the same red felspar, with broad flakes of mica in them. It may as well be called hornblende granite, or micaceous syenite as greenstone." This brief, but clear, account of its macroscopic appearance, while it leaves little now to be added, impresses one with the high degree of culture to which the observing eye had been trained by the fathers of geology, long ere the resources of microscopical science had been called in to solve its problems. The rock forms a nearly vertical dyke with parallel walls, intrusive in the contorted calcareous shales. The dyke, as is common to our series, can be traced only for a few yards continuously ; at low water, it is seen to end abruptly along a joint-existing prior to its intrusion. It is about 8 feet thick, and presents a bold mural face to the south some 9 feet high ; an additional 4 feet below being descernable in the water.

Macroscopically, hand specimens shew a small-grained reddish-brown rock of uniform texture, enclosing nests of somewhat larger

flesh-coloured crystals ; each cluster lying within an envelope of black mica, which, in optical transverse section, forms a border or frame to the brighter coloured crystals within. The crystalline structure is finer near the margins of the dyke than in the middle where the nests become conspicuous. A few blebs of iron-pyrites shine out from the exposed face. The joints are few in number, dividing up the dyke into bold cubical masses. Weathering produces a light-brown earthy face, in which the original mineral constituents are no longer distinguishable.

Microscopically, the most prominent features on a polished face are the sections of hornblende, these in all cases being best seen by reflected light. They are of a pale greenish-grey tint, either hexagonal sections parallel with the basal plane, or longitudinal sections parallel to the face of the long prism (Fig. 3). By transmitted light (Fig. 1), the notable character is the entire absence of a glassy base, the whole of the component materials being well crystallised out. The orange-red felspar crystals are very uniform in size, with their rectangular boundaries sometimes fairly well defined. They yield the extinction angles of orthoclase, but generally the crystals are much altered by the development, especially when in contact with hornblende, of microfelsitic matter polarising (Fig. 5) in blue-milk tints, and of a faint greenish-white colour by reflected light. With higher powers these decomposition products are seen to follow the lines of cleavage (Fig. 4). It is proposed to recur to this characteristic structure when dealing with the incipient schillerization to which some of the ingredients of these Mica-traps have been subjected. The hornblende crystals have clear boundaries, within which the felspar never intrudes. The crystallization of the hornblende preceded that of the felspar. The characteristic cleavages of hornblende are only faintly indicated in transverse sections of this nearly colourless type, which is no longer dichroic ; nor are the usual fibrous striations to be detected in the longitudinal sections. The mica, which is plentiful, and remarkably fresh, is the uniaxial biotite, giving the maximum of extinction between crossed-Nicols when viewed at right angles to the basal plane. The hexagonal plates are olive-brown, transverse sections

taken across the cleavage being a little paler: both are strongly dichroic. The plates are very free from microscopic enclosures, but numerous transparent acicular microliths and globulites, following three directions crossing at an angle of 60°, are revealed by higher magnification (Fig. 6). Where disintegration has set in, *e.g.*, slides cut near the exposed surface, the biotite is spotted with ferric oxides arranged often parallel with the cleavage planes, or symetrically within the basal plates (Figs. 7 and 11). Further, the plates are occasionally bent and driven apart, with their ends frayed out, where the supporting felspar or hornblende has been dissolved out. Here we see the earlier stages in the disintegration of this secondary biotite (Figs. 12 and 13). The clusters of felspar crystals enclosed by mica, noticed in the hand specimens, have here also representatives of microscopic dimensions (Fig. 15). An incipient foliation is at some points simulated by the biotite plates, showing a tendency to arrange themselves parallel with the margin of the dyke, as though the shearing stress had here been more intense. Magnetite and apatite being the first to crystallize, are included within all the later-formed minerals—the former appearing as octohedral plates, or granular patches (Fig. 21), and the latter in sharply defined colourless hexagonal prisms. Much of the magnetite, however, in these sections, especially if cut from near the exposed face of the rock, appears as secondary skeletal crystals (Figs. 12 and 14), or irregular plates having their margines converted into translucent red hæmatite (See Fig. 1), or opaque brown flecks of limonite. Sparsely distributed rhombohedral plates or grains of titaniferous iron, occasionally surrounded by an opaque border of leucoxene are also usually associated, as is the magnetite, with an altered condition of the biotite as previously described (Figs. 1 and 12). Among the secondary products of degradation may be noted quartz in clear colourless crystals, or crystalline grains; scales of kaolin opaque by transmitted, white by reflected light; a very pale green mineral indefinite in outline, not dichroic and not polarising; dolomite in polygonal grains or scattered dust strongly chromatic (rich green and pink tints under crossed Nicols); and specks of pyrites. Lastly, calcite, as an infiltration from the overlying carboniferous limestone,

easy to identify by its two cleavage planes and its chromatic effects, fills in all the vacated cavities in such abundance as to cause the rock to effervesce very freely. (Fig. 23).

To sum up, the rock then is holocrystalline, its essential constituents being orthoclase, hornblende and biotite : it is therefore a Mica-syenite. So far as is known it stands unique among British rocks. Its nearest allies lie in the mountains of the Vosges. We may compare, for example, the specimen and slide, No. 582, in the Museum of the Geological Laboratory, Royal School of Mines, S. Kensington : described as a Mica-syenite from Cleury, Vosges. Omitting paragenetic indications, this specimen may be regarded as typical of what our rock may have been in its pristine purity ; and if, as is stated, the Vosges Mica-traps perceptibly alter the rocks with which they come in contact, the analogy may be further extended inasmuch as our Mica-syenite dyke metamorphoses, the calcareous shales towards which it hades, into a highly-crystalline limestone band, some two inches in thickness.

(2) On an inspection of the six-inch Ordnance Survey Sheet, No. 96, it will be seen that, about 350 yards below Pecca Steps, Thornton Beck bends eastward towards Manor House. The bed of the stream is formed in part by a trap dyke, extending for several yards from the east end of this bend. It is difficult of access save when the water is very low, only a small portion of the dyke lying exposed, under a tree, upon the north bank of the stream.

Macroscopically, this rock has a somewhat fullers-earth like appearance, due to the mixture of a greenish-grey, with a creamy-coloured earthy decomposition product, the former probably after biotite, the latter felspar. Along the southern boundary of the dyke, it is of a steel-grey tint, the plates of black mica here being still visible. The calcareous shales in contact therewith have assumed a crystalline aspect.

Microscopically, along with a profuse development of biotite in a matrix of grey decomposition products, we have in abundance sections which, at first sight, suggest pseudomorphs after Olivine (Fig. 16, 17) and Nepheline (Fig. 18.9. See also Fig. 2). There are no indications of hornblende by reflected light, nor can any outlines of felspar be made out. We shall return to this shortly.

(3) If the strike of the above dyke be prolonged under Manor House to Dale Beck it connects with a third Mica-trap dyke about 20 yards lower down that stream than our dyke No. 1, running parallel therewith, and having like it, a slight hade to the south. The exposed rock mass is about 15 feet long, 8 feet in height, and 5 or 6 feet in breadth, and it is interesting as being the most southerly exposure known of Mica-trap in the British Islands. This dyke was extremely puzzling, especially along its northern boundary, where it presents an appearance which, for a long time, was interpreted as that of a decomposed spherulitic rhyolite, which indeed in numerous hand specimens collected at various times it closely resembles: flow-structure; impure Kaolin alternating with chalcedony in concentric layers or envelopes enclosing a central black degradation product, with other indications all pointing to this conclusion.

But the microscopic appearance (Fig. 20) does not confirm, nor is the silica sufficiently abundant to sustain this reading ; and indeed repeated surveys of the junction *in situ* have sufficed to demonstrate that considerable reaction has taken place between the dyke and the contiguous shales, the mutual interchange obliterating the line of contact, along most of the exposure, while at one or two points where it remains visible it is extremely irregular and eroded, the two having eaten into each other persistently. The simulation of spherulitic structure alluded to, is due to the fact that the highly contorted gnarled effects, superimposed upon the original bedding planes, being more or less retained have formed, as it were, an initial path along which the alteration of the shales has travelled.

This trap both macro- and microscopically, a little way from its northern boundary, is identical with our dyke No. 2, showing that the latter also owes its alteration to the interaction of the trap and the contiguous shales. Where the removal of the biotite has been completed the rock is vesicular, but along its southern margin it is less decomposed. Some twelve feet from the stream this face resembles the contiguous dyke No. 1, that is, it consists of an intimate mixture of red-felspar and black-mica, the latter much more abundant than we found it in our first dyke: but on the other hand a polished

surface shews horn-blende to be entirely wanting. Throughout the sections of these dykes these two minerals are so constantly present relatively in inverse ratio as to justify the inference that the ingredients of the biotite have been derived from the bleached hornblende.

Are these three dykes then related? The study and comparison of an extensive series of slides may enable us to attempt an answer to this enquiry. The first slide prepared (in 1879) from near the surface of dyke No. 1 was so much decomposed that it became necessary to obtain deeper-seated and better-preserved specimens. If we arrange in groups, say (1) Slides well preserved from dyke No. 1: (2) surface of dyke No. 1 : (3) Best preserved south side of dyke No. 3: (4) Slides taken from south to north of dyke No. 2; we shall find an insensible gradation in the modifications which the essential constituents of the primary hollocrystalline Mica-syenite have undergone.

The slides of group (1) we have already described as consisting of clearly outlined orthoclase, bleached hornblende and fresh biotite. Group (2) show decomposing hornblende difficult of identification, with relatively more biotite than is found in the previous group. The slides of group (3) are devoid of hornblende, and rich in biotite. The felspar in each case becomes less and less definite, both in outline and colour. In slides of group (4) the individuality of the felspar crystals is gone, while of hornblende there is no further trace. Finally, the four groups show conclusively that the apparent pseudomorphs after olivine (Figs. 16 and 17), are produced by the decomposition of the clusters of bent and separated plates of biotite, as seen in transverse sections (Figs. 12 and 13); while the appearance of a cross-section of zoned nepheline (Figs. 18 and 19), compare (Fig. 8, 9, 10, and 11) is simulated by the decomposition products of similar plates when viewed in the direction of the main axis. Intermediate stages are usually present (Figs. 21, 22, and 23). From these petrographical observations we are led to infer, that were we to follow these three dykes down to their origin, we should find them springing from a common magma.

Explanation of Plates.

All the figures were drawn with camera lucida, by transmitted light, unless otherwise stated.

Plate 18a

Fig. 1. Mica-syenite. About 100 yards below the last slate quarry, Dale Beck, Ingleton. × 50.

Fig. 2. Mica-syenite. 350 yards below Pecca Steps, Thornton Beck, Ingleton. × 50.

Plate 19.

Fig. 3. Hornblende. Sections in outline, by reflected light. × 25.

Fig. 4. Orthoclase felspar. Crystal altered along cleavage lines. × 240.

Fig. 5. Do. Microfelsitic structure, under crossed Nicols. × 240.

Fig. 6. Biotite mica. Microliths arranged in three directions. × 350.

Fig. 7. Do. Ferriferous products following cleavage planes. × 130.

Fig. 8 to 11. Do. Ferriferous products symetrically arranged in relation to the basal plane. × 10 × 60 × 130 × 250.

Fig. 12. Biotite mica. Bent plates, and skeletal crystals of magnetite. × 25.

Fig. 13. Do. Bent and frayed-out plates more highly magnified. × 130.

Fig. 14. Magnetite. Skeletal crystals. × 25.

Plate 20.

Fig. 15. Felspar cluster enclosed by biotite. × 25.

Fig. 16. Fictitious pseudomorphs after olivine. × 60.

Fig. 17. Do. do. × 20.

Fig. 18. Do. after zoned nepheline. × 60.

Fig. 19. Do. do. × 60.

Fig. 20. Calcareous shales, altered by contact. × 10.

Fig. 21. Biotite plate passing to the zoned nepheline stage. × 60.

Fig. 22. Do. do. Olivine stage. × 25.

Fig. 23. Calcite infilling cavity, lined by biotite. × 25.

1.

2

Mintern Bros. Chromo lith.

TATE. THE LAMPROPHYRES.

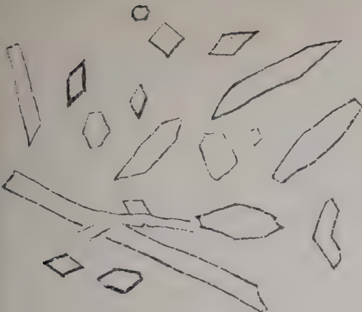
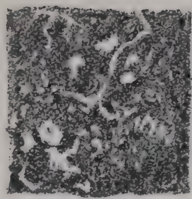


FIG. 3. ×25.



× 240. N ×.

FIG. 5.

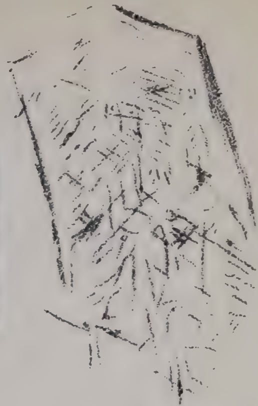
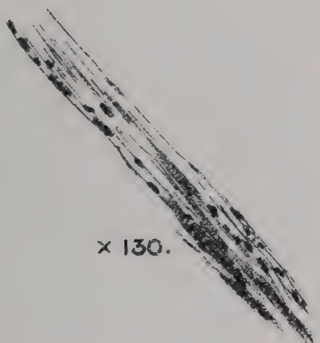


FIG. 4. ×240.

FIG. 6. × 350.



× 130.

FIG. 7.

FIG. 8. ×130.

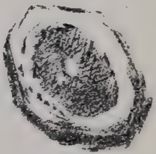


FIG. 11. × 60.

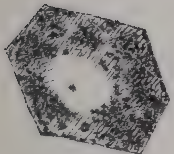


FIG. 9. ×250.

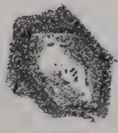


FIG. 10. ×10.

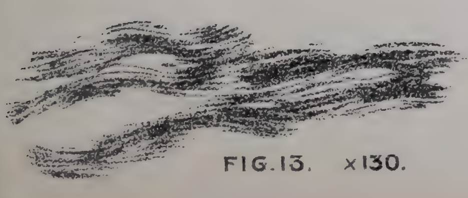


FIG. 13. ×130.

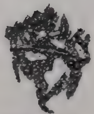


FIG. 14. ×25.

FIG. 12. ×25.

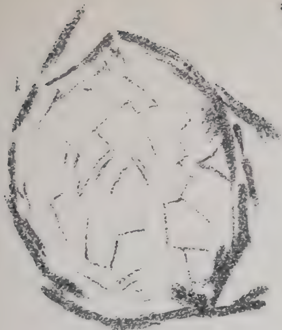


FIG. 15. × 25.

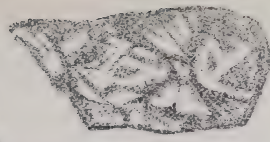


FIG. 17. × 20.

FIG. 16. × 60.

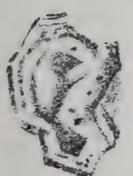


FIG. 19. × 60.

FIG. 20. × 10.

FIG. 18. × 50.

FIG. 22. × 25

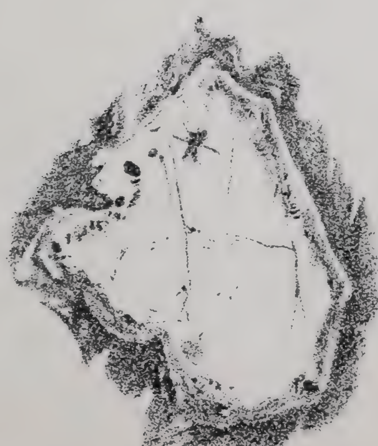


FIG. 21. × 60.

FIG. 23. × 25.

REPORT ON THE BURIED CLIFF AT SEWERBY, NEAR BRIDLINGTON.

BY G. W. LAMPLUGH.

Introduction.

During the course of my enquiries into the geology of this neighbourhood, I learnt that the tusk of an elephant had once been found in the cliff near Bridlington Quay by some fishermen, and I sought out one of the men, and questioned him as to the discovery. He told me they found the tusk in a bed of soft sand at the bottom of the cliff near where the chalk ends, about two miles east of Bridlington Harbour, opposite the village of Sewerby; but, when I came to examine the section, I could find no bed like that described, though I noticed that the chalk ended very abruptly, and also, that though the lower part of the cliff was much obscured by slipped drift, there were indications of beds between the boulder-clay and the chalk. I called attention to the discovery in a paper on "The Speeton Shell-bed" (in Geological Magazine, Dec. II., Vol. VIII., p. 174), and suggested that the remains had been obtained from some unexposed bed which underlay the boulder-clay.

The lower part of the section remained masked by slips till the winter of 1883-4, when the sea cleared away much of the displaced stuff, and revealed the long-looked-for bone-bed. I was first apprised of this by one of the fishermen who had made the previous discovery, who came to tell me that there were two bones in the cliff. I examined these bones, and thought that the greater part of a skeleton might lie concealed, and, not then having leisure myself to excavate the bed I acquainted my friend Mr. J. R. Mortimer, who at once sent workmen to extricate the remains. The bones, however, proved to be isolated and disconnected, and not members of a series; nor were they, as I had surmised, the bones of the elephant whose tusks had been found, but were referable to *Bos*, or *Bison*.

No further exploration was made at this time, but a few months later Mr. Clement Reid of the Geological Survey, who was at work on the Holderness drifts, visited the section, and finding it of

importance, had a cutting made, to show the sequence of the beds. He afterwards gave a sketch and short description of the place in his most admirable Memoir on Holderness,* which is, so far as I know, the first and only published account.

Acting on Mr. Reid's suggestion, that further investigations should be made, the Yorkshire Geological Society granted last spring the sum of £10 towards the expenses of more extended excavation; and it has been my very agreeable duty to assist my friend and neighbour, Mr. Thomas Boynton (late of Ulrome), in the superintendence of this work.

Before we could commence, it was necessary to obtain the permission of the Lord of the Manor and owner of the land on the adjacent cliff, the Rev. Yarburgh Lloyd Greame, of Sewerby House, and the warmest thanks of the society, and of all interested, are due to that gentleman for his courteous acquiescence in our scheme.

We started to excavate with two workmen on the 20th of July last, and with two more on the 25th, and worked on until the 6th of August, when the section was visited by the members of the society. We first cut a trench from the shore-line into the cliff at right angles, so as to show as complete a section as possible, and then excavated, for the space of about 40 feet, the deposits and talus which were banked against a buried cliff of chalk, revealing a very clear and instructive section, as shown in the sketch (Fig. 2). During the course of this work a very large number of bones, teeth, and other remains were unearthed, which, by a vote of the society, have been presented to the Museum of the Yorkshire Philosophical Society at York, on condition that they be kept together in a separate case as "The Sewerby Collection."

An Ancient Shore.

The chalk which forms the bold headland of Flambro', ends abruptly on the south-west in an ancient sea-cliff. This cliff makes no feature at the surface, for the boulder-clays and gravels which lie so thick above the chalk on the south side of the headland, sweep on and obliterate the escarpment, so that, were it not for the coast-

* Geological Survey Memoir: Holderness: pp. 47-49.

section, we should remain ignorant of its existence. It is easily traceable, however, in the cliff near Sewerby, and, under favourable conditions when the slipped drift which obscures the section is washed away, there is to be seen, banked against the buried cliff, a series of deposits older than the boulder-clay which lies above the chalk. These beds contain a profusion of mammalian and other remains, and differ from anything known elsewhere on the coast. The series comprises, in ascending order, A. an old sea-beach. B. an old land-surface. C. a mass of blown sand; and these will be separately described. The sea is now cutting back obliquely into the ancient shore-line, the recent chalk-cliff joining the old chalk-cliff at a slight angle, but, as in the new so in the old, there have evidently been many little bays and recesses, so that the trend is by no means regular, and may at any time change.

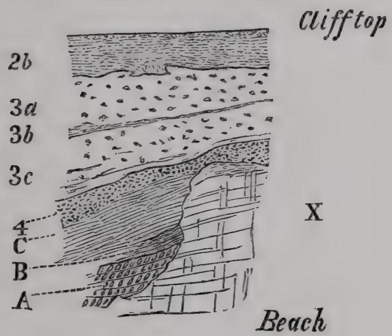


Fig. 2. Section of Cliff at Sewerby.
Scale, 60 feet to 1 inch.

	Top Soil	2 to 3 ft.
2b.	Well-bedded Chalk Gravel, "The Sewerby Gravel," about	12 „
3a.	Brown Boulder-clay ... ... „	15 „
3b.	Stratified Seam of Silt and Gravel	1 to 2 „
3c.	Dark Boulder-clay	12 „
4.	Rough Chalk Rubble	1 to 2 „
C.	Clean Blown-sand...	about 25 ft.
B.	Clayey Chalk-wash: an old land-surface ... ... „	5 „
A.	Old Sea-beach of rolled chalk pebbles ... ... „	5 „
X.	Ancient Cliff of Chalk ——— ... ... „	35 „

The total height of the present cliff at this place is about 75 feet, but the buried chalk cliff has a height of only about 35 feet, the remaining 40 feet consisting of the overlying glacial beds. These beds are not clearly exposed, but seem to be as in the preceding complete section (Fig. 2), wherein are shown the beds from top to bottom of the cliff.

The beds lying above the old cliff need not be more particularly described in this report, but I shall have occasion to refer to them again in considering the age of the underlying deposits.*

A. The Old Sea-beach.

In our excavation we always found, at the bottom, resting on a floor of solid undisturbed chalk and abutting against the base of the old cliff, a sea-beach of rolled blocks and pebbles of chalk with a little sand, having a thickness of from 3 to 5 feet. Where it lay lowest the bottom of this bed was just below the present high water mark, so that its upper layers were generally slightly above the level of the highest tides, but only so slightly that a stormy sea might yet overwhelm it. I think, however, that a slight elevation of the land or withdrawal of the sea is indicated, for the waves seem, in old times as now, to have reached to a higher level than the shingle, the cliff being sea-worn for two or three feet above the beach. In one place we uncovered a short shallow cave, a little over a foot in diameter and three or four feet in length, which the waves had hollowed out in the face of the cliff. Among the shingle were many rolled bones both of mammals and of fish, these being most plentiful close to the cliff-foot, whither, being lighter than the stones, they had evidently been flung by the breakers of a rough coast. A few marine shells were found in the sandy layers (see list below), and many of the chalk blocks were perforated by *Pholas*, *Saxicava*, or *Cliona*, but the shells had in all cases decayed out of the boring.

Though the chalk of the adjoining cliff contains no flint, nor do the cliffs anywhere on the south side of the headland, there was a

* For a fuller account of these beds, see Reed's "Holderness," or my papers in Proc. Yorksh. Geol. Soc. for 1881, 1882, and 1883.

scattering of flint pebbles among the chalky shingle ; but all the flints we found had come from the Yorkshire chalk, and among them there were none of the foreign red and black flints, such as occur plentifully in our boulder-clays, so that the pebbles have no doubt drifted along the coast from the north side of the headland, or have been brought by fresh water down the Boynton valley. Foreign pebbles were not, however, absent, for at rare intervals we threw out worn fragments of sandstones, quartzites and basalts ; but these erratics were very scarce, forming only an infinitesimally small proportion of the whole, and the largest was no larger than a child's clenched hand. Fragments of a black carbonaceous shale, such as occurs in some of the estuarine beds of the Oolite, were rather more plentiful, and we rarely passed a day without finding three or four pieces of it ; this, being very light, may have drifted along the coast.

B. The Old Land-surface.

Resting on the old beach was an irregularly stratified mass of marly clay, with sub-angular lumps of chalk and thin streaks of sand, evidently talus and rain-wash from the impending cliff. This indicates that the sea no longer reached the cliff, the change having been very gradually brought about, as was shown by the way in which the lower part of the rain-wash intercalated with the old beach Bones were rarer in this deposit than in the beds below, but occurred here and there in the clayey layers, along with numerous small land-shells and obscure traces of vegetation. Remains of fish were of course absent, but we found a tooth of a small rodent, probably the vole, and several birds' bones, besides the remains of the larger mammals.

The thickness of this bed close to the old cliff was from four to six feet, but it thinned rapidly as it left the cliff, and, at a distance of from 5 to 10 yards, generally disappeared by dovetailing into the blown sand, into which it also passed gradually upwards. It has evidently accumulated in the sheltered hollow between the sand-dunes and the cliff, and is of peculiar interest as affording us the only land-surface yet known in our Yorkshire coast-sections.

C. The Blown-sands.

A mass of clean yellow sand without admixture, save for a few angular blocks of fallen chalk, and an occasional bone, overlapped the chalk-wash and was banked up against the old cliff to its full height, even passing in places over its brow. In this mass there were obscure bedding-planes which dipped down towards the cliff, showing that the sand at first accumulated as a high dune fringing the cliff, but afterwards filled up the hollow and drove on over the sloping wold. As in the old beach, so here, there were evidences of violent and persistent storms from the south, or from some quarter between south-west and south-east. The sand has been driven against the hard chalk for so long and with such force that the whole face of the cliff has been beautifully smoothed and rounded, as I have attempted to show in my sketch. Mr. Reid has already pointed out how striking is the contrast between this smooth outline and the rugged angular features of the adjoining recent cliff. I think that the action of a sand-laden blast would not alone produce this difference, unless there were also a more or less complete absence of frost, but to this I shall revert later.

These blown sands may once have been much thicker, and perhaps have extended for some distance over the surface of the chalk, but they are now cleanly cut out at the top of the cliff by the chalky rubble (4) which is nearly continuous over the chalk and seems to form the base of the drifts.

The glacial beds above the blown sands contain no contemporaneous fossils—unless indeed a few fragmentary shells in the boulder-clay be so considered.

The Fossils.

Among the fossils found the following have already been recognized, and it is possible that when the collection has been put in good order, and thoroughly examined, additions may be made to the list.

The asterisks in the columns indicate in which bed the fossil was found.

The only fossils before recorded are *Cervus megaceros*, and *Bos* or *Bison*, by Mr. C. Reid.

My thanks are due to Mr. Clement Reid, and to Mr. H. M. Platnauer, for their kind assistance in making this list.

Fossils from the Sewerby Cliff-beds.		Old Beach.	Chalk Wash.	Blown Sand.	Remarks.
Elephas (primigenius ?)	The Mammoth.			*	Four molars, three from the old beach, and one from the blown sand; one molar seems to belong to the Mammoth, the others probably to E. antiquus.
Elephas antiquus.	The Elephant.	*			
Rhinoceros, sp.	Rhinoceros.	*			Three or four molars, and portion of a lower jaw.
Hippopotamus, sp.	Hippopotamus.	*			A badly preserved tusk.
Equus, sp.	The Horse.	*			A single tooth.
Cervus (*megaceros ?*) and perhaps another.	The Irish Elk.		*	*	Teeth, lower jaw, &c,
Bos primigenius.	The Urus.	*	*	*	Many bones.
Bison ? sp.		*	*	*	Do.
A small rodent: probably the Vole. ...			*		An incisor.
A Carnivor, perhaps Hyena				*	Indicated by gnawed bones.
Birds			*		Three or four limb bones
A Snake				*	Portion of a jaw.
Teleostean Fish		*			Vertebræ, and bones of the head abundant.
Land Mollusca.					
Helix hispida			*		
Helix pulchella			*		
Pupa muscorum			*		
Marine Mollusca.					
Purpura lapillus		*			
Littorina litorea.	The Periwinkle.	*			
Ostrea edulis	The Oyster.	*			
Mytilus edulis.	The Mussel.	*			
Pholas		*			Indicated by borings only.
Saxicava		*			Do.

The bones, except when from the drier parts of the blown-sand, were very soft and friable, and were generally so crushed and fractured that it was very difficult to remove them. This was no doubt in part due to the quantity of fresh water which has flowed out of the chalk and percolated through the lower part of this section on its way to the beach, where it yet forms a series of fine springs on the foreshore. In the old beach the bones were generally water-worn and rounded, as might be expected, and this was also sometimes the case

in the chalk-wash, but in the blown-sand they were frequently quite unworn, and in one or two instances had their finer angles and delicate muscular markings so beautifully preserved that I am inclined to think they must have been protected by flesh when embedded. We did not, however, except in one doubtful case, find articulating bones lying together; on the contrary they occurred sporadically in all the beds, and were nearly always fractured, with portions wanting. Though no identifiable remains of carnivorous animals have yet been found, the marks of their teeth could be traced on several of the bones from the blown-sand, and it seems to me that we are probably indebted to them for the presence in the midst of an æolian deposit of heavy fractured isolated bones too weighty to have been carried by the wind. There could be no more suitable habitat for beasts of prey than the sand-dunes and cave-worn cliffs of a coast-line abandoned by the sea.

The fish remains which occurred so plentifully in the old beach consisted chiefly of vertebræ and head-bones, the latter often lying loosely together in such a way as to show that they had been held together by ligaments when thrown up by the waves. The marine shells were very scarce, and badly preserved, but this did not surprise me, as, even under favourable conditions, it is not often that many shells are found at high-water mark on a rough stony beach. The list is too short to be of much palæontological service, but the presence of Ostrea, which does not occur in the arctic shell-beds of the Basement Clay at Bridlington Quay, shows that the climate was temperate. The land-shells are such as now live on sand-dunes, and have no especial interest, except that they show how complete has been the withdrawal of the sea.

Careful search was made for any evidence of man's presence, but no recognizable trace has yet been found, though the situation is a not unlikely one, and the fauna is that with which he is elsewhere associated.

Age of the Beds.

In discussing the age of these deposits I can at present add very little to what has already been advanced by Mr. Reid, though I am inclined to demur at his placing the beds under the heading of

Interglacial, as I think the evidence tells strongly towards their *Preglacial* age—that is, if the term *Preglacial* may be applied to beds older than the oldest truly glacial deposit known in East Yorkshire.

There is this serious difficulty in understanding the stratigraphical relations of the beds ;—the boulder clay which rests on the chalk or chalk-rubble in the cliff-sections east of Sewerby, has always been considered to belong to the lower division of the Purple clay : and it is this clay which, as I have recently found, passes down over the blown-sands to the foot of the cliff west of Sewerby. But at Bridlington Quay a still lower boulder-clay, with well-marked lithological and palæontological peculiarities, known as the "Basement" clay, is seen, and can be traced in the cliff eastward for a short distance and then disappears beneath the beach.—Now, these bone-beds, though they are undoubtedly older than the Purple clay, are they also older than the Basement clay ? And if so, what has become of the Basement clay? Is it entirely absent from our section ?

There is so much slipped ground and obscurity in the cliff between Bridlington Quay and Sewerby, that one cannot be quite positive that the boulder-clay (3c. of Fig. 2) which overlaps the bone-beds is not the Basement clay that has re-appeared, especially since boulder-clays in general show such a noble disregard for levels and horizons. But I do not think this to be the case, and am inclined to believe that, if the Basement clay is present at all, it is represented by the band of chalk-rubble (4) which also passes down from the top of chalk to the shore, thickening very materially as it sinks. This rubble seems to have resulted in some way from the action of ice on the surface of bare chalk, and its formation may well have been contemporaneous with that of the Basement clay on the lower ground. This is a point which I hope to elucidate in our next year's excavations, and I will withhold further comment on it till then.

Had there been any pre-existing glacial beds in the neighbourhood when the old beach was being formed, they could scarcely have escaped erosion, and would have yielded a plentiful scattering of erratic pebbles in the ancient shingle just as in the recent beach,

but we find instead that stones of any kind except of chalk, are so few and far between that it required a thorough and systematic process of excavation to find them.* A single stranded mass of ice might yield far-travelled pebbles enough for miles of such a beach.

Both the sea-beach and the blown-sand seem to indicate that the prevalent wind of the period came from somewhere between south-east and south-west; and that a mild climate resulted is shown not only by the presence of oysters among the shingle, but also by the state of the old cliff-face, to which attention has already been called. Its sand-worn surface is so unbroken that anyone who has studied the rugged broken features of the present cliff, or has watched for himself the effect of even a slight frost on a chalk escarpment, will at once be convinced that there can have been very little frost when this cliff was carved out.

The fauna itself, as at present known, does not aid us much in determining the exact age of the deposits. There seems to be nothing in it to prove whether the beds are pre-glacial, glacial, or post-glacial, though it shows that they cannot belong to the older Tertiaries.

The shell-bed at Speeton,‡ though at a much higher level above the sea, is probably of approximately the same age as these deposits, and there are also certain valley-beds at Danes Dyke, and at two or three other places on Flambro' Head that hold similar positions between the glacial beds and the chalk, but no animal remains have yet been obtained from them.§

The preservation of this little triangular patch of incoherent beds beneath the boulder-clay is one more proof, if that were needed, of the southerly flow of the ice over the headland during glacial

* Not reckoning the fragments of carbonaceous shale, we never came across more than three or four foreign pebbles in a day, and I think I could have carried away all we found in my pocket.

Since this was written the winter frosts have come, and the exposed portion of the old cliff has completely lost its smooth outline.

‡Supra cit. Geol. Mag., sec. ii., vol. viii., p. 174.

§ A steep cliff of chalk with angular gravel banked against it, has also recently been exposed in the deep railway cutting north of Flambro' Station, but this seems to be a valley wall of late glacial or post-glacial times, the gravel containing many drift pebbles, and probably forming a continuation of the "Sewerby gravels."

times. If this old shore could be followed I suspect we should find the deposits cut out wherever the cliff line trends north and south, and preserved only where it runs east and west so as to afford a "lee-side." Pre-glacial cliff-and-valley-escarpments in the neighbourhood which face north or north-east, often show signs of displacement and surface contortion.

Concluding Notes.

At the period when these beds were being deposited Flambro' Head was already in existence as a bold headland of chalk-cliffs, and the stormy billows of an open sea already beat upon it. But it formed a far more striking feature than at the present day, for not only did it then reach out further to seaward, but the sea also ran far inland under its flanks, the whole of Holderness being under water, and the chalk cliffs instead of ending with the headland as at present, stretched on in a long line that followed the sweep of the Wolds across Yorkshire and Lincolnshire, broken only by a few shallow creeks running into the land and by the deeper estuary of the Humber. The climate was mild and equable, but now and again a stray mass of ice from afar may have drifted into the bay, telling of changes to come.

Then there came a slight alteration in the level of the land, or, it may be, only in the set of the tides, so that the waves of the sea could no longer reach their former bounds and a long sandy beach began to form in many places at the foot of the cliffs. And sometimes the wind at low tide seized this sand and drove it up in eager clouds to build up a growing line of sand-dunes under the shelter of the abandoned cliff; and bye-and-bye these sand-dunes topped the cliff, and the sand drove on over the sloping wold.

Then, in later times the ice came down, filling the sea-bed with its huge glaciers, pressing hard against the coast till it reached the northern face of the headland and there, piling itself higher and higher, it over-rode the great cliffs and poured over into the bay, and and coalesced with other masses that had come far from the north-east. And in its course it passed smoothly over these sheltered beds, preserving them for our study under its rough mantle.

Such is one chapter in the great history of the headland, and now the sea is slowly coming to its own again, and as it marches to

its old place at the Wold-foot, Holderness, that relic of the ice-age, is gradually vanishing, and its clays and gravels are somewhere going to make the foundations of a newer land.

REFERENCES TO PLATE No. 21.

A. Old Beach.	C. Blown Sand.	X. Old Chalk Cliff.
B. Rain Wash.	S. Slipped Drift.	Q. Bridlington Quay. (About one mile distant, South-West.)

NOTE ON A FOSSIL SPECIES OF CHLAMYDOSELACHUS.

BY JAMES W. DAVIS, F.G.S., ETC.

Some years ago a Selachian was obtained by Prof. H. A. Ward, which had been caught off the coast of Japan. It was purchased for the Museum of Comparative Zoology at Harvard College ; and in January 1884 Mr. S. Garman, of that Museum, gave a preliminary description of the fish in the "Bulletin of the Essex Institute," vol. xvi., in which he recognized it as belonging to a new family and instituted for it the genus *Chlamydoselachus*.

I had the pleasure of describing this fish and giving a historical resumè of the various opinions respecting it in the proceedings of this society, at a meeting held in 1885.* Until the month of June in the present year, no fossil representative was known. Whilst visiting the Natural History Museum at South Kensington, I came across a fossil representative of the genus closely resembling the recent one.

It is extremely interesting to find that ten years ago a fossil representative of *Chlamydoselachus* was actually discovered and figured by the late Robert Lawley. The specimen is from the Pliocene beds of Orciano in Tuscany, and is described as very rare ; the teeth figured are possessed of three sharp, slender, backwardly-curved denticles, with a base forming a broadly-expanded plate divided at its posterior extremity into a pair of prongs, which doubtless extended, as in the existing species, beneath the succeeding tooth, thereby gaining additional firmness and strength. The figures indicate a tooth twice the diameter of the anterior teeth of the existing species. The author knew of no living or fossil representative of the teeth, and gave the figure with a short notice, without

* Proc. Yorksh. Geol. and Polyt. Soc., vol. ix., p. 98.

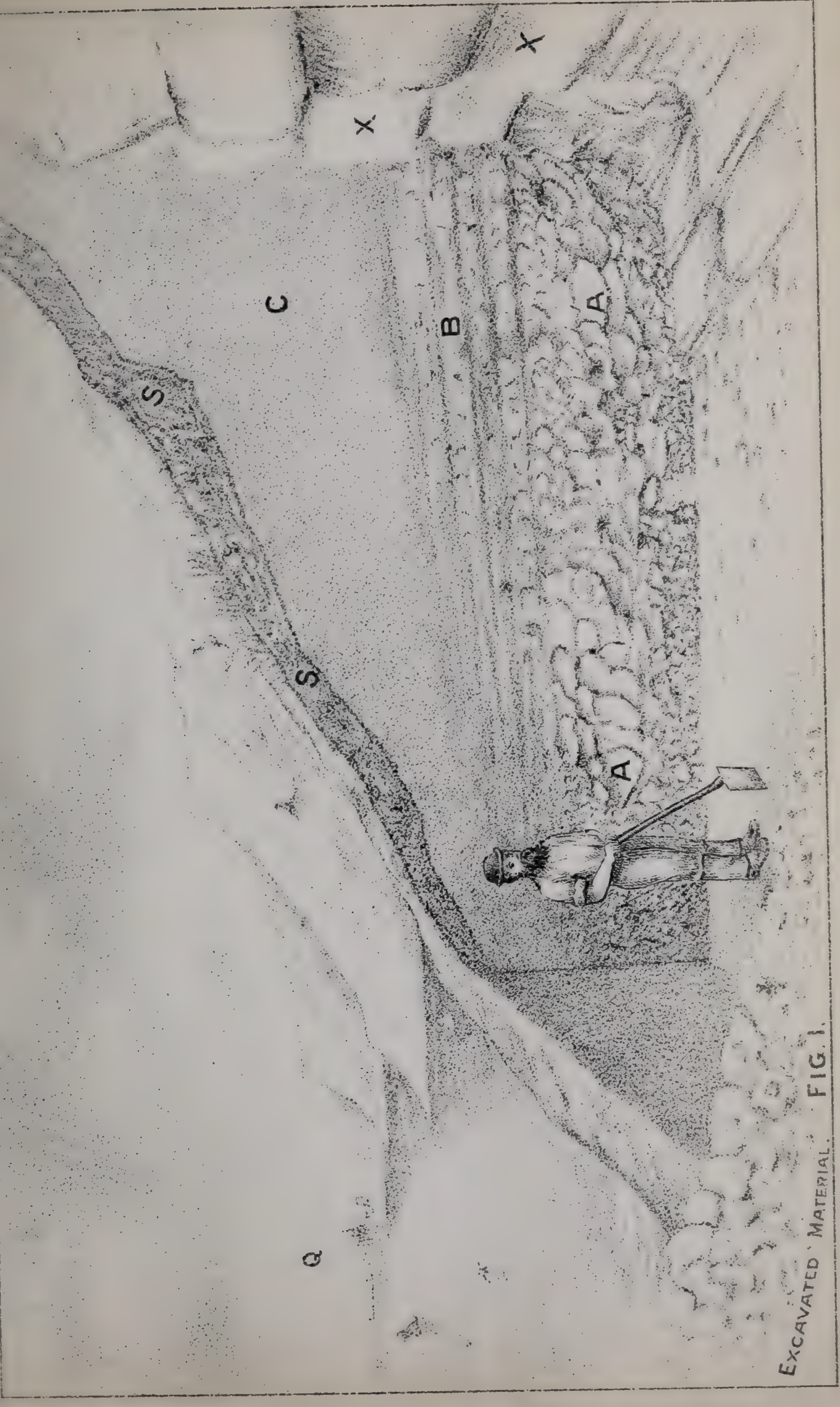


FIG. 1.

BURIED CLIFF AT SEWERBY, JULY 1887

description or appending to it any distinctive name. There can be no hesitation therefore in associating the fossil with the existing genus, and it may not be inappropriate to append the name of Mr. Lawley and distinguish it specifically, *Chlamydoselachus lawleyi.*

The figures will be found in "Nuovi Studi sopra ai Pesci ed altri Vertibrati fossili delle colline Toscane," di Roberto Lawley, published at Florence in 1876, pl. i. figs. 1-1*c*. I am indebted to Mr. G. A. Boulenger for the opportunity of comparing them with the teeth of the recent *Chlamydoselachus* in the British Museum.

NOTES ON THE DISTRIBUTION OF THE ENTOMOSTRACA IN THE WENLOCK SHALES. MR. MAW'S WASHINGS. BY GEORGE ROBERT VINE.

PART I.—BUILDWAS BEDS.

In the proceedings of the Yorkshire Geological and Polytechnic Society of last year,* I gave a paper on the Palæontology of the Wenlock shales of Shropshire, together with a list of species found in the now celebrated washings of Mr. Maw. Originally these shales, over twenty tons, were washed, for the purpose of selecting the Brachiopoda from the remaining *debris*, to help the late Dr. Davidson in his descriptive work on this group of organic forms. In the paper referred to I also gave full descriptions of the various horizons of the Wenlock shales, so far as supplied me by Mr. Maw, both below and above the Wenlock limestone. At the time I wrote the list was unavoidably incomplete as the Ostracoda not having been fully described by Messrs. Jones and Holl, the specific names had to be filled in from MS. notes furnished to me, subject to alterations, by Professor T. Rupert Jones himself. The notes on the Ostracoda of the shales now given, treat of the published descriptions of Messrs. Jones and the late much-lamented Dr. Holl. During the progress of the British papers, Prof. T. R. Jones received for examination in 1886 "A fine series of Ostracoda from the Silurian rocks of Gothland," supplied by Prof. G. Lindström, of the State museum, Stockholm. As many of the species in the Gothland list belong to

* New series, vol. ix., pl. ii., pp. 224—248.

what Dr. Lindström designates the "Shale beds of Northern Gothland—cœval with the sandstone of South Gothland," (No. VI., p. 8, see Bibliogr.)—or equal to our Wenlock shale, it may be interesting to note the range of species identified by the authors of the papers referred to above, both in the British and the foreign strata of the same geological age. I have also several examples of Ostracoda from similar American horizons, but as I am unable to refer to published descriptions of the same, I feel that it would be unwise to treat of them in connection with the detailed published descriptions by the authors already named. This will be a gain, rather than a loss to the Palæontologist, because I am certain that if the American Upper Silurian shales were as honestly searched for Ostracoda as our own and the Scandinavian shales have been, many forms new to the Palæontologist would be added to the list now given, or a wider range of British and Scandinavian species established.

In the following notes I deal more particularly with my own findings, rather than with those furnished to Professor T. R. Jones by Mr. John Smith, of Kilwinning: not because I have any desire to force my own to the front, but because I have picked my collection of Ostracoda from well-defined and numbered beds in the shales. In passing I shall give due prominence to the species supplied by Mr. Smith, as there are a few forms met with in his collection which are apparently absent in mine.

After Messrs. Jones and Holl had completed their labours on both collections, I went over, carefully, my stock of material again, picking out and mounting a very extensive series of known and unknown forms from the finer *debris* of the various beds, and in this sense the present paper may be looked upon as an original contribution rather than a mere compilation. Beginning with the lower beds and ascending to the highest, I have catalogued the whole of the species in my present collection stratigraphically, so that future workers on the same beds, or even other beds, higher and lower in the Silurian series, may compare and complete the range of species both in space and in time. The work of Professor T. R. Jones and Dr. Holl has been so honestly carried out, that I cannot promise the reader descriptions of new species in this re-working, and so carefully

has the measuring of the specimens described been executed by Mr. C. D. Sherborn, that on this head, too, our wants are well supplied, but what these respected authors could not do, in the absence of my later work, is all that I can promise to supply on the present occasion.

Until quite recently I was unacquainted with the shale *debris* of the Ludlow beds. A few months ago Mr. G. W. Shrubsole, F.G.S. of Chester, turned over to me some pickings from Mr. Maw's washings (3½ tons of shales), but I have searched them in vain for Ostracoda, but the remains of Annelida, chiefly *Cornulites scalariformis*, Vine, are so abundant, that I regret I did not possess the Ludlow washings while I was writing my paper on the "Annelida Tubicolæ of the Wenlock shales."*

In the Gothland list of species referred to above, the following forms are catalogued as found in the series of Swedish rocks which Professor Lindström characterises, as equal to our Wenlock shales. There are, however in the list, names of several species, and some few genera, which, up to the present time, I have not succeeded in obtaining, and with this list before him the student will be able to compare the range of our own with the range of Swedish species.

THE SILURIAN OSTRACODA OF GOTHLAND.

Horizon of Wenlock Shales only.

1. Macrocypris Vinei, Jones.
2. Bythocypris symmetrica, J.
3. " concinna, J.
4. " Hollii, J.
5. Thlipsura v-scripta, J. and H., var. discreta, J.
6. Æchmina bovina, J.
7. †Cytheropsis? bisulcata, Kolmodin.
Bursulella, Jones, 1887.
8. † " unicornis, J.
9. †Beyrichia clavata, Kolm.
10. " Klœdeni, var. granulata, J.

* Quart. Journ. Geol. Soc., Aug., 1882.

† Not as yet found in the British strata of W.S.

11. Beyrichia Klœdeni, var. antiquata, J. *
12. † ,, Bolliana-umbonata, Reuter.
13. †Leperditia nitens, Kolm.
14. † ,, tuberculata, Kolm.
15. † ,, phaseolus, Hisinger.
16. † ,, balthica, His.
17. †Entomis reniformis, Kolm.
18. †Primitia lævis, J.
19. ,, valida, J. & H.
20. (?) ,, grandis, J. Near *P. valida*, J. & H.
21. (?) ,, reticristata, J. Near ally to *P. cristata*, J. & H.
22. ,, seminulum, J.
23. † ,, inequalis, J.

Primitopsis, Jones, 1887.

24. † ,, planifrons, J.
25. † ,, ,, var. ventrosa, J.

Out of this list of twenty-five species, ten at least are found in the British Wenlock shales, and two, Nos. 20 and 21 in all probability, may be found amongst examples that, up to the present time, have been overlooked. I have a peculiar example of *P. valida* to catalogue from the Coalbrookdale beds, that has not as yet found a place, as a variety, in our lists. There might be other unrecorded forms of which I may have to speak when I come to deal with the other beds. Neither species of *Leperditia*, nor *Entomis* has been found in our British Wenlock shales.—Of the other new genera, *Primitopsis* and *Bursulella*, I cannot speak of yet, with any degree of satisfaction.

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I have only given the papers of Messrs. Jones, Holl, and myself, in which the Ostracoda of the Wenlock shales are dealt with specially.

I. Notes on the Palæozoic Bivalved Entomostraca, No. XX. Annals & Mag. Nat. History, April, 1886, pp. 337-363.

II. Ibid. No. XXI., A. M. Nat. Hist. May, 1886, pp 403-414.

III. ,, No. XXIII., A. M. Nat. Hist. March, 1887, pp. 177-195.

IV. ,, No. XXIV., A. M. Nat. Hist. June, 1887, pp. 400-416.

* B. Kloe. var. tuberculata Salter Catalogues, but given as appearing in Upper Ludlow beds only.

† Not as yet found in the British strata of W.S.

‡ The four papers of Messrs. Jones & Holl are illustrated with nine plates, and all the new species are described and figured.

V. List (provisional) of species of Entomostraca, found by Mr. John Smith, in Upper Silurian Shales, Shropshire. Geol. Mag. dec. ii., vol. viii., 1881, pp. 44-48.

VI. Notes on some Silurian Ostracoda of Gothland. Prof. T. R. Jones, F.R S., F.G.S. Stockholm, 1887.

VII. Provisional list (Vine) Quart. Journ. Geol. Soc., Vol. XXXVIII., 1882, pp. 44-48.

VIII. Notes on the Palæontology (lists of species, &c.) of the Wenlock shales. Vine. Proc. Yorksh. Geol. Soc. Vol. IX., pt. ii., 239-248.

A full List of ENTOMOSTRACA (up to date Jany. 1888), found in the Wenlock Shales. Prof. T. R. Jones, F.R.S.

MACROCYPRIS, G. S BRADY, 1867.

[p., page. pl., plate. f., fig. or figs.]

1. ,, Vinei, Jones & Holl, III.,* p. 179, pl. iv., f. 1, 2, 3 and Woodcut.

2. ,, elegans, Jones & Holl, III., p. 180, pl. v , f. 8, a.b.c.

3. ,, siliquoides, Jones & Holl, III., p. 181, pl. v., f. 9, a.b.c.

4. ,, symmetrica, Jones, III., p. 181, pl. vii., f. 8, a.b.

5. ,, alta, Jones, III., p. 181, pl. v., f. 10, a.b.

6.(?) ,, crassula, Jones (Holl's collection. Unique). III., p. 181, pl. vii., f. 9, a.b.

PONTOCYPRIS. G. O. SARS. 1865.

7. ,, Mawii, Jones, III., p. 182, pl. iv., f 4, a.b. and f. 7.

8. ,, ,, var gibbera, Jones & Holl (*Ibid* f. 6).

9. ,, Smithii, Jones & Holl, III., p. 184, pl. iv., f. 5, a.b.

BYTHOCYPRIS, BRADY. 1880.

11. ,, Hollii, Jones III., p. 184, pl. v., f. 1 a.b., f. 2, pl. vi., f. 3, a.b., and f. 4, a.b.

10.(?) ,, reniformis Jones, id. p. 185, pl. vi., f. 1-2, &c.

12.(?) ,, botelloides J., id. 185, pl. vii., f. 2, a.b.

13. ,, testacella J., id. p. 186, pl. v., f. 5 a.b.c.

14. ,, symmetrica J., id. p. 186, pl. vii., f. 3 a, (var. 3 c,) 4 a.b. (var. b) & 7 a.b. (var. a.)

15. ,, concinna J. III., p. 186, pl. v., f. 6, a.b.c. & 7, var. ovalis.

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* See Bibliography.

BYTHOCYPRIS, BRADY. 1880.

16. ,, Phillipsiana J. & H. III., p. 187, pl. v.,
17. ,, ,, var. (major) J. & H., id f. 3. a.b.
18. ,, ,, var typica J. & H., id. f. 4, a.b.c.
19. ,, pustulosa J. & H., pl. 188, pl. vii., f. 13, a.b.
20.(?) ,, seminulum J , id. pl. vi., f. 9, a.b.
21. ,, acina J., id. 189. pl. vi., f. 10, a.b.
22. ,, phaseolus J., id. 189, pl. vii., f. 11, a.b. f. 12, a.b.

THLIPSURA JONES & HOLL, 1869.

23. ,, corpulenta J. & H., IV., p. 401, ref.*
24. ,, tuberosa J. & H., id. ref.*
25. ,, angulata J., id. p. 402, pl xii. f 9 a.b.
26. ,, plicata J., id. p. 402, pl. xii., f. 10-13.
27. ,, v-scripta, J. & H., id. 403, ref.*

OCTONARIA JONES, 1887.

28. ,, octoformis Jones IV., p. 404, pl. xii., f. 2, a.b.
29. ,, var. intorta J., id. pl. xii., f. 3, a.b.
30. ,, ,, simplex J., id. 405, pl. xii., f. 4, a.b.
31. ,, ,, informis J., id. pl. xii., f. 5, a.b.
32. ,, ,, bipartita J.. id. pl. xii., f. 6, a.b.
33. ,, ,, persona J., id. pl. xii., f. 7, a.b.
34. ,, ,, monticulata J., id. 406, f. 8, a.b.
35. ,, undosa J., IV. p. 406, pl. xii., f. 1, a.b.
36.(?) ,, paradoxa J., id. p. 406, pl. xiii., f. 12.
36A. ,, sp. J., (id. p. 407 reference).

CYTHERE, MULLER, 1785.

37. ,, Hollii, Jones III., p. 190, pl. vi., f. 5, a to c, f. 6, a to c.
38.(?),, Vinei, J. & var. III., 191, pl. vii., f. 1, a.b. 5, a.b.
39.(?),, subquadrata, J., id. 191, pl. vii., f. 6, a.b.f. 14 a.b.

CYTHERELLA, JONES AND BOSQUET, 1849.

40. ,, Smithii, Jones III., page 192, pl. vii., f. 15, a.b.f. 16 a.b.

XESTOLEBERIS G. O. SARS., 1865.

41. ,, corbuloides Jones & Holl, IV. p. 410, ref. = Cythere id.
42. Cytherellina ? sp. (An. Mag. Nat. Hist.) & III. p. 185.

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* See Annals & Mag. Nat. Hist. Series 4. Vol. III., 1869, pp. 214-215 for descriptions and figures.

ÆCHMINA JONES & HOLL, 1869.

43. ,, cuspidata J. & H. IV., p. 411, pl. xiii., f. 2, f. 3 a b., f. 4 a.b.c. & f. 9.

44 ,, bovina J., id. 412, pl. xiii., f. 5, a.b.c & 6, a.b.c.

45. ,, depressicornis J., id. p. 413, pl. xiii., f. 7, a.b.c.

46. ,, brevicornis J., id. p. 413, pl. xiii., f. 8, a.b.

47. ,, sp. ?

BEYRICHIA, M'COY; 1846.

48. ,, tuberculata, var, gibbosa, Reuter. I. p. 349, pl. xii, f. 1 a, d.b.

49.? ,, Klœdeni M'Coy. 1846.

50. ,, ,, *var.* granulata, Jones (I., p. 350, pl. xii., f. 2.)

51. ,, ,, ,, nuda J., (I.. p. 351.)

52. ,, ,, ,, antiquata J., (I., p. 351.)

53. ,, ,, ,, intermedia J., (I., p. 352, pl xii., f. 3-4.)

54. ,, ,, ,, subspissa J, & H., (ibid. f. 3.)

55. ,, ,, ,, subtorosa. J., (I, p. 353, pl. xii, f. 6-7.

56. ,, ,, ,, torosa, J., (ibid. p. 354.

57. ,, ,, ,, tuberculata, Salter. (I., p. 354, pl. xii, f. 8, a b. f. 9, a.b.)

58. ,, ,, *sub-var.* clausa, Jones (ibid. p. 355, f. 9.)

59. ,, concinna, J. & H., (I., p. 356, pl. xii., f. 22, a,b.

60. ,, Maccoyiana, Jones I., p 357, pl. xii., f. 11, 12, 13.

61. ,, Jonesii, Boll I., p 359, (see for references)

62. ,, admixta, Jones & Holl (I., p. 359, pl. xii., f. 5.)

63. ,, lacunata, Jones and Holl I., p. 359, pl. xii., f. 18, 19, 20.

BOLLIA, JONES & HOLL, 1886.

64. ,, bicollina, J. and H., I., p. 361, pl. xii., f. 14, 15, 16.

65. ,, uniflexa, J. and H., I., p. 361, pl. xii., f. 17, a.b.

69. ,, Vinei, J. and H., II., p. 406, pl. xiii., f. 14.

70. ,, ,, *var.* mitis, J. and H., id. pl. xiii., f. 13.

68. ,, auricularis Jones, IV., p. 408, pl. xiii., f. 10, a.b c.

66. ,, interrupta J., id. pl. xii., f. 14.

67. ,, ,, var. ? (elongata, Vine.)

KLŒDENIA JONES & HOLL, 1886.

71. ,, intermedia J. and H.

72. ,, ,, *Var.* marginata, J. and H., I., p. 362, pl. xii., f. 21, a.b.

STREPULA, JONES & HOLL. 1886.

73. ,, concentrica, J. & H., II., p. 404, pl. xiii., figs 1, 4, and 6.

74. ,, irregularis, J. & H., II., p. 404, pl. xiii., figs. 5, 7, 8, 9, and 15.

75. ,, beyrichioides, J. & H., II, p. 405, p. xiii., f. 2, 3.

PLACENTULA, JONES AND HOLL. 1886.

76 ,, excavata, J. and H. II., p. 407, pl. xiii., figs. 10, 11, 12, and 16.

MOOREA, Jones and Kirkby, 1867.

76a. ,, Smithii, Jones, IV., p 409, pl. xiii, f. 11, a.b.

PRIMITIA, JONES & HOLL. 1860.

77. ,, lenticularis, J. & H., II., p. 408, pl. xiv., f. 1a, 1b.

78. ,, Rœmeriana, J. & H., id, p. 408. Reference.*

79 ,, fabulina, J. & H., II., p. 408, pl. xiv., f. 2, 1c.

80. ,, variolata, J. & H., id., 408. Ref.*

81. ,, paucipunctata, J. & H., II 409, p. xiv., f. 3

82. ,, humilis, J. & H., II., p. 409, pl. xiv., figs. 6 a., 9 a., b.c.

83. ,, valida, J. and H., II., 409, pl. xiv., figs. 7, a.b c., and III., p. 193, pl. vi. f. 7.

84. ,, ,, *Var.* breviata, J. and H, II., p. 410, pl. xiv., f 8.

85. ,, ,, angustata, J. and H., id., f. 4. a.b.

86. ,, tersa, J. and H., II., p 410. Ref *

87. ,, umbilicata, J. and H., id. Ref.*

88. ,, cristata, J. and H., id., p. 411. Ref.*

89 ,, cornuta, J. and H., id.. p 411, pl. xiv., figs. 12-13.

90. ,, ornata, J. and H, II., p. 411, pl. xiv., f. 5.

91. ,, æqualis, J. and H, II., p. 412, pl. xiv., f. 11, a.b.

92. ,, diversa, J. and H., II., p. ,, ,, ,, f. 10, a.b.c.

93. ,, seminulum, J. and H., II., 413, ,, ,, f. 14, a.b.c.

94. ,, furcata, J. and H., II., ,, ,, ,, f. 15, a.b.

95. ,, obliquipunctata, J., IV., p. 409, pl. xiii. f. 1, a.b.c.

96. ,, punctata, Jones, III, p. 193, pl. vii., f. 9, a.b.

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* Ann. Mag. Nat. Hist., Ser. 3, vol. xvi., 1865.

STRATAGRAPHICAL DISTRIBUTION OF THE OSTRACODA IN THE WENLOCK SHALES.

(I. Buildwas Beds, only.)

1. Lower Wenlock Shale represented by the following numbers : Nos. 22, 37, 36, 38, 40 ... ... "Buildwas Beds."

II. Middle Wenlock Shales—No. 43. "Coalbrookdale Beds."

III. Upper Wenlock Shales—Nos. 41, 42, 25. "Tickwood Beds."

(a) Wenlock Limestone.

IV. Shales over Wenlock Limestone—Nos. 24, 46.

(b) Ludlow Series.

The materials supplied to me by Mr. Maw as "Washings from the Buildwas Beds," were in five different packages, of which Nos. 22 and 37 were the least in bulk, and No. 40 the greatest. Nos. 36 and 38 were in separate boxes about 8 inches square and 6 inches deep—No. 40 was nearly double this size : whilst Nos. 22 and 37 were in very small cigar boxes. The organic *debris* were results of the washings of several tons of shale. To obtain the Ostracoda now given I rewashed the various packages, and in this way I got some really good samples of the finer clay, which, when sifted, was examined by the highest power of my hand-glass, and the Ostracoda picked out with a fine camel's hair pencil. In Nos. 22 and 37 a great variety of forms were obtained—but though my fine clay from the Nos. 36, 38 and 40 beds were more abundant than from the shales of the other two numbers—both individuals and species of Entomostraca were far less. This will be noted by referring to the stratagraphical list. Associated with the Entomostraca in the shale debris of Nos. 22 and 37 were innumerable fragments of Trilobita of several species, but rarely perfect forms, so we may consider the *debris* of these two numbers in all probability as similarly characteristic, but I regard the Ostracoda, of all the shales below the Wenlock Limestone, as belonging to the age of the shale deposits, rather than as being *derived* species from any former Silurian age. I am not so positive about the other organisms, but even most of these seem far less water-worn than species from the Coalbrookdale beds. The Ostracoda, however, except where some of the examples are broken by the washings of myself and Mr. Maw, are generally perfect,

and the outlines of the valves very sharp; while their ornamentations in many cases are fully preserved. There is apparently in some of the examples, a slight compression of the valves which I cannot account for, otherwise nearly the whole of the forms appear to me to be normal in their different stages of growth.

The large number of specific forms that have been added to our Silurian Catalogues of Ostracoda are due to the keen intelligence of Messrs. Jones and Holl, rather than to those who picked out the Entomostraca from the shale. In some of the mounted series there was much difficulty in seperating the forms, previous to mounting, hence two, and even three species, are sometimes placed together on one slide, but this drawback has been got over by the authors on account of the way in which the individual specimens are seperately numbered, both in my own, and in Mr. Smith's collection. The figures, to which all students are referred, are valuable, but the examples are so chronicled in the series that disputes respecting the authorship of species can be easily settled by a reference to the numbered slides

The Nos. 22 and 37 are the lowest of the fossiliferous zone of the Buildwas Beds, but the Ostracoda, nevertheless, are given seperately.

(*a*) Buildwas Bed, No. 22.

Macrocypris symmetrica, Jones and Holl.	(Not common).
,, siliquoides, J. and H.	,,
Pontocypris Mawii, J. and H.	(Common).
,, ,, var. gibbera, J. and H.	,,
Bythocypris symmetrica, J. and H.	(Not common).
,, pustulosa, J. and H.	,,
,, phaseolus, J. and H.	,,
Thlipsura v-scripta, J. and H. *Var.* discreta (?) Jones.	
Cythere (?) Vinei. J. and H.	
Cytherella Smithii, J. and H.	(Rare).
Beyrichia Klœdeni M. Coy.	
,, ,, *Var.* granulata, J.	
,, ,, ,, ,, with big lobes.	
,, ,, ,, tuberculata Salter.	(Common).

Bollia bicollina, J. and H. (By no means common).
,, interrupta, J. ,,
Primitia paucipunctata, J. and H. (Rare).
,, humilis, J. and H. (Common).
,, diversa, J. and H. (Very rare).*
,, punctata, J.

(*b*) Buildwas Beds. No. 37.

Pontocypris Smithii, J. and H. (Unique).
Bythocypris (?) botelloides, J. and H. ,,
Octonaria (?), paradoxa, J.
Cythere (?) subquadrata, J. and H.
Beyrichia Klod, *var.* intermedia, J.
Bollia bicollina, J. and Holl.
,, ,, small var. like fig. 16 (See *Biblio. ante*, No, I.)
,, Vinei, J and H.
,, ,, var. mitis, J. and H.
,, interrupta, J.
,, ,, an elongate var.
,, ,, ,, with big lobes.
Klœdenia intermedia, J. and H., var. marginata, J.
Primitia humilis, J. and H., large var.
,, ,, ,, small var.
,, cornuta, J. and H. 2 examples.
,, ,, small var. Fig. 13. (See *Biblio. ante*, No. II.)
,, fabulina, J. and H.
,, diversa, J. and H.

(*c*) Buildwas Beds. No. 36.

Macrocypris Vinei, J. and H. (Unique).
Bythocypris Hollii, Jones).
,, symmetrica, J.
Cythere subquadrata, J.
,, (?) Vinei, J.
Bollia bicollina, J. and H.
,, interrupta J. (Very rare in this washing).

* The species marked "very rare" and "rare" in the lists, must be taken as indications of my own experience in the collecting: the "very rare" are generally unique examples.

Primitia diversa, J. and H.
,, humilis, J. and H. (large var.)
,, ,, ,, (small var.)
,, punctata, J. (One poor example.)

(*d*) BUILDWAS BEDS. No. 38.

Macrocypris Vinei, Jones. { *(Very fine examples; larger than any figured).
,, ,, (Smaller examples as figured).
Bythocypris symmetrica, Jones.
,, phaseolus, J.
Cythere (?) Vinei, J.
,, subquadrata, J.
Primitia humilis, J. and H. (large and small var.)

(*e*) BUILDWAS BEDS No 40.

Macrocypris Vinei, Jones and Holl. (Medium size as figured).
,, elegans, Jones. (Unique).
Pontocypris Smithii, J. (One poor example).
Thlipsura v.-scripta, J. and H.† *Var.* discreta? J., same as in No. 22.
Bollia bicollina, J. and H. (Very fine).
Primitia humilis, J. and H. (Both varieties).
,, cornuta, J. and H. (Unique example).

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* These examples more closely resemble the Swedish forms, especially with regard to the graceful curving referred to by the author.

† In Professor T. Rupert Jones' paper on some Silurian Ostracoda from Gothland (No. 6, Biblio, pp. 6 & 7), the author describes a var. of *T. v-scripta* in which "the front salcus is oblique, being not quite perpendicular, and those on the hinder half of the valve kept slightly apart, not closing together to form the letter V." The two examples placed as above are near allies of the Gothland forms, only that the front salcus is oblique but not so nearly perpendicular as the author points out.

As the compilation of these papers will entail upon me additional research—which means time and labour—I feel compelled to break them up into series, of which the preceding is a first instalment. The next one will treat of the Ostracoda of the Coalbrookdale and Tickwood Beds.

Corrections: Vine, Palæontology of the Wenlock Shales.
Proc. York. Geol. Soc. Vol. ix., pt. II. New Series. 1887, pp. 239-248.

Will the reader oblige by correcting a few of the inaccuracies in the nomenclature of species in the lists, as above.

p.	240	after No.	39	read	Chætetes cyclosus, Quenst.
p.	241	,, ,,	80	,,	Macrocypris Vinei Jones.
,,	,,	,, ,,	89	,,	symmetrica, J. & H.
,,	,,	,, ,,	95	,,	Cythere corbuloides, J. & H.
,,	242	,, ,,	123	,,	berichiodes, J. & H.
,,	,,	,, ,,	126	,,	Rœmeriana, J. & H.
,,	243	,, ,,	147	,,	var. siluriensis, Vine.
,,	,,	,, ,,	167	,,	delicatulus, Vine.
,,	244	,, ,,	194	,,	didyma, Dal.
,,	246	,, ,,	256	,,	Acroculia, sp.

In the cols. devoted to Mr. Smith's collection delete head lines Annelida tubicola on pp. 246, 247, and 248.

In col "Localities" read Dormington Hill—9 lines from top and after No. 120.

ON THE OCCURRENCE OF QUARTZITE AND OTHER BOULDERS IN THE LOWER COAL MEASURES AT WORTLEY, NEAR LEEDS.

BY CHAS. BROWNRIDGE, ASSOC. M.I.C.E., F.G.S.

The presence of boulders in the coal measures in various localities affords matter for interesting speculations bearing on the conditions under which the deposition of the carboniferous strata took place. Boulders have been found and recorded from the coal-fields of Leicestershire, Lancashire, Derbyshire, North Staffordshire, and the Forest of Dean, but none appear to have been recorded from this immediate district.

The position where these boulders were found is situate in the fork of land bounded by the London and North Western and Great Northern Railways, the Gelderd Road and the Farnley Beck. They were got from the pit known as 'No. 1 Black Bed pit.' The whole of this neighbourhood is worked for the Wortley fire-clay by Messrs. Ingham and Sons. Above the fire-clay the better bed coal is got, and at a still higher level the black bed coal and the outlying iron-stone are worked. It was in the last-named beds that the specimens were found. The depth of the black bed coal from the surface is here 30 feet. The largest of the boulders is a coarse gritstone, nearly spherical in shape. Its dimensions are 2 ft. 6 in. by 2 ft.; it has a fairly smooth polished face, with slight striæ. This was found embedded in the 'bind' or clayey shales, just overlying the

coal. The other three boulders (or pebbles) are quartzites and much smaller in size, varying from 11 in. by 9 in. to $3\frac{1}{4}$ in. by $2\frac{1}{2}$ in., and were all found embedded in the black bed coal itself. Two of the specimens are more angular in general shape than the third, but in all of them the angles or edges are well rounded off, and the faces polished.

Mr. T. G. Bonney, F.R.S., &c., to whom two sections of the quartzites have been submitted, kindly describes them as follows:—
"The grains in the rock are remarkably well rounded, the "majority are quartz but there are some grains, also rounded for "the most part, which are brown in color, more or less opaque. I "I think it possible that these are decomposed felspar, stained by "infiltrated bituminous material. The quartz grains are cemented "by secondary quartz, sometimes, but not always, in optical "continuity with the adjacent grains. Cavities appear to be frequent "in most grains, but are generally of very small size; sometimes a "tiny bubble may be noted, but I think that they are commonly "empty, some grains contain a number of small almost colorless "belonites, rather like sillimanite, which are commonly seen in the "quartz of certain old granitoid rocks; others contain a flake of "brown mica, a tiny crystal or two, probably an iron oxide or a "crystallite which may be zircon. I expect the quartz has been "derived from an old granitoid rock. The well rounded grains "difference this specimen from those quartzites or grits which I have "hitherto seen from boulders in coal, but a specimen which I "obtained from one of the old quartzites of the Lickey Hills also "contains many well rounded grains, and so does a quartzite in the "Charnwood series, of course I do not mean to suggest that we must "look in this direction for the parent rock."

Of a second specimen Mr. Bonney remarks:—"This rock differs "but little from the last, the grains, as a rule, I think are not quite "so well rounded, and rather more are stained; those containing the "belonites are perhaps not quite so common. A small grain may be "brown tourmaline, and I think this mineral is also included in a "quartz grain. It is very probable that this boulder comes from the "same parent rock as the other one."

Prof. Bonney in his presidential address to the Geological section of the British Association at Birmingham in 1886 described several boulders found in coal, the examination of which he rightly considers to be of great value from the light they may throw upon the physical conditions existing in the carboniferous period.

The reason why these stones are thus found located in such peculiar positions can only at present be surmised, as the subject is at present rather vague ; but the theory has been adduced that they have been carried down to their present position by masses of floating vegetation in a manner similar to that recorded by travellers on the Amazons, &c., where, in the swamps and shallows such masses are seen floating, carrying foreign matter along with them. It has also been suggested that there have been circumstances analagous to those at present in Siberia where the plains—something like the old coal-measure plains—are surrounded by lofty ice-covered mountains, and boulders are borne into these plains by glaciers. A leading London newspaper recently reported a similar specimen and alleged it to be a meteorite. This singular idea although thus made popular is however untenable.

ON A MAMMALIFEROUS GRAVEL AT ELLOUGHTON IN THE HUMBER VALLEY. BY G. W. LAMPLUGH.

Hearing last May that a large bone had been found in a gravel pit at Elloughton near Brough-on-the-Humber, I went at once to examine the place. The 'bone' proved to be a mammoth's tusk of large size, and on enquiry I learnt that the pit had yielded many other bones and teeth, but as they were all badly preserved the workmen had taken little care of them. This seems to be a new locality for mammalian remains, though it has long been known that they occur in the gravels which lie between the chalk and the boulder-clay at Hessle six miles to the east of Brough, and also in a deposit of doubtful age at Bielbecks, seven miles to the north.

The pit, which had been open about twelve months, is excavated into the top of a small isolated hill known as Mill Hill, and as there has since been a continuous removal of the material, a good section

is now exposed. The hill, rising out of the low-level flat formed by the Humber warps, about a mile from the river, forms an outlier of the Wolds, from which it is separated by a spread of low ground less than a mile in width. It is made up of solid Jurassic beds with a capping of gravel.*

The following section was exposed in the pit at the time of my visit, and it may stand as a type, for though the beds have varied in thickness during the excavation they have remained essentially unaltered.

Figure 1. *Scale.* 10 feet to an inch.

X Top-soil etc. ... . $2\frac{1}{2}$ feet.
A Rough stony gravel with some sand ... about 9 feet.
Containing pebbles of flint, sandstone, red chalk, oolite limestone, and other local rocks; also a few well-worn erratic pebbles of felstone, quartzite, etc.; also rolled lumps of clay; and thin seams of clay, and of carbonaceous matter.
B Yellow sand with stony layers. ... about 5 feet.
Stones similar to those in gravel above; the mammoth's tusk and other animal remains found in this bed.
O Hard grey clay, probably belonging to estuarine oolites ... thickness uncertain (see note.)

* The workmen in the pit gave me the following particulars of a well sunk to supply Mr. Lyon's new house on the brow of the hill.

6 inches dirty gravel.
10 feet clean clay.
1 ft. 6 in. soft sandstone rock.
—— Black shaly clay.

In this section all except the top item seem to belong to the oolites, but it is difficult to say what beds they represent. The 'soft sandstone' *may* be the Kellaways Rock—but if so, it is remarkably thin here—and the clay below, the Great Oolite Clay.

The rough gravel, A, contains some boulders of oolitic rocks of large size, one which I measured being, roughly, 3 feet by 2 feet by 2 feet. The character of these boulders does not often favour the preservation of glaciation-marks, but in one or two instances I noticed partially-obliterated grooves which may have been due to ice ; at any rate the size of some of the blocks suggests that floating ice was the agent of their transportation, especially since the gravel is at a higher level than the oolitic rocks in the immediate neighbourhood, from which the boulders may have come. Pebbles foreign to the district form only a small proportion of the whole, and their size is always small. The bones, etc., do not occur in this part of the section, but, as the workmen informed me, among the yellow slightly clayey sand B in the lower part of the pit.

Though the sand, B, contains many pebbles, there is a marked difference between it and the overlying rough gravel, and their junction shows a line of erosion and unconformity. However, as the whole of the beds are current-bedded and irregular this does not necessarily imply anything more than contemporaneous denudation ; at the same time, in a low ridge about a mile to the westward, an extensive excavation reveals rough current-bedded unfossiliferous gravels, much resembling in character those in this pit, and it may be that the two gravels are conterminous, and that the sandy bed B is the remains of an older deposit.

The tusk mentioned at the commencement of this paper lay exposed in the floor of the pit in stony yellow sand about a foot above the bottom-clay. Judging from its size and condition I do not think it can have been carried far by running water ; it has more probably either been transported from a shore-line by floe ice, or has dropped from the floating carcase of the animal. Its length at the time of my visit was 90 inches, but the workmen said they had broken up about two feet of the thick end before they were aware ; and as the apex also was blunted and badly preserved, I think its length when deposited cannot have fallen short of ten feet. Its diameter was 6 inches at a distance of ten inches from the apex ; $7\frac{1}{2}$ inches at 20 inches ; 8 inches at 30 ; $8\frac{1}{2}$ at 40 ; and beyond this it did not seem perceptibly to thicken. Its curvature was not

great, and would lie within a breadth of about 20 inches. It was in a very friable state, and though I enclosed it in cement, it crumbled into small cubical fragments when an attempt was made to remove it, and nothing but this *debris* remains.

The only other fossils that I have so far had an opportunity to examine are a few fragmental teeth and limb-bones, which may all be referred to the mammoth, except one tooth belonging to a horse. The fauna of the pit, as known to me, is therefore as follows :—

Elephas primigenius.

Equus. sp.

I aminformed however that other bones have been obtained and sent to Leeds and Hull, so that this list may yet be extended. Analogous deposits elsewhere in the Riding contain a larger fauna, and I should at least expect *Rhinoceros*, *Bos* or *Bison*, and *Cervus* to occur in addition to those already found. I made careful search for shells, but could find none except those in a fossil condition washed out of the secondary rocks.

In the absence of boulder-clay it is hazardous to attempt the correlation of this deposit with the Hessle or Kelsey Hill beds, but the presence of far-travelled stones in the gravels show that at any rate it cannot be preglacial, while its height above the present level of the Humber and the size of some of its boulders are evidences that it cannot have been much later than glacial times. The non-occurrence of marine shells suggests fluviatile conditions, and it is possible that the beds have accumulated in fresh water when the drainage of the Lower Humber was encumbered and the waters dammed back by ice. The sudden withdrawal of this icy barrier might explain the rather curious preservation of these incoherent gravels on the crest of an isolated hill with bare slopes, for under such conditions the hill might emerge as an island and the deposits on its summit be preserved while its slopes were undergoing torrential denudation.

But there is no part of Yorkshire of whose topography during glacial times we know less than of the inner slope of the Wolds and the plain at its foot, denudation on the slopes and deposition on the low-ground having equally obscured the phenomena, and while so

much uncertainty remains it is impossible to deal satisfactorily with isolated beds like these. I have an impression that these gravels may be the inland representatives of the Kelsey Hill beds, and may be newer in age than the Hessle beds, but the evidence for this is weak and inconclusive, and need not be stated.

My best thanks are due to H. Lyon, Esq., the owner of the pit and the residence adjoining, for his kindness in permitting me to try to remove the tusk, and for his aid in various other ways.

ON THE ANCIENT FLINT-USERS OF YORKSHIRE.

BY JAMES W. DAVIS, F.S.A., F.G.S., ETC.

In July, 1886, a paper was communicated to a meeting of this society,* "On the remains of a primitive people in the south-east corner of Yorkshire," by Thomas Wright, F.S.A. The author describes a number of flint implements which had been collected by Mr. Edward Tindall, of Bridlington, and Mr. Cape, also of that town. He states that there were implements of various kinds made of chipped flint, among which the most common were arrow-heads, and others, similar but larger, which had probably been used for spears or javelins; delicately-formed fish-hooks also chipped from flint, knives, saws, chisels, sling stones, and flat stones. The latter were sharp at the edge, and probably had served the purpose of scrapers to remove the internal fleshy part from the skins of animals. Occasional stone axes were found scattered over the district. Mr. Tindall informed the author, that the arrow and spear heads were most frequently found on the slopes of moorland on the sides of rather steep hills; the sling stones were found in the greatest abundance in and near Flamborough; ruder arrow-heads were found in the neighbourhood of Sewerby, three miles from the head; and that those of most perfect make were found furthest inland. Another circumstance of which particular mention is made is that the flints occur in certain areas with much greater frequency than in others, and an observant person could not walk across those fields without finding specimens lying on the surface. Mr. Wright argues from this, that these areas are

* Proceedings of the Yorksh. Geol. and Polyt. Society, vol. iii., p. 46.

probably the sites of ancient manufactories of flint implements, and the occurrence in considerable numbers of flint-flakes and cores, besides the highly-finished implements, affords some corroboration of the opinion.

Since Mr. Wright's observations were made numerous geologists, with antiquarian proclivities, have made collections of flints from the same district, and the flat lands of Holderness and the environing wolds have furnished very large numbers of examples to their cabinets. At the present time, flint objects, even on fields which have been recently ploughed, are rarely met with, and it is only occasionally that a good example is discovered by an intelligent workman, a few of whom are constantly on the alert.

The flint implements discovered on the wolds of Yorkshire and in Holderness, furnished many illustrations to the classical work of Dr. John Evans, F.R.S., on the "Ancient Stone Implements, Weapons and Ornaments of Great Britain." Each of the groups into which the implements are divided is represented by Yorkshire specimens, and in several instances the whole of the examples on which the group is established have been obtained from the wolds. It is unncessary to enumerate them, a reference to the work, admirably illustrated, will show the important place occupied by the Yorkshire specimens.

In addition to the flints found on the surface of the ground throughout the wold district of the East Riding, which of themselves do not afford a very large amount of insight into the character and the habits of the people: there are others which have been discovered in the mound-graves common in the same district. The explorations of Rev. Canon Greenwell, of Mr. J. R. Mortimer and others, have shown that the mounds may be clearly divided into two periods, in the later of which bronze is found; whilst in the earlier, only stone implements have been discovered, and these are similar in form and workmanship to those found on the surface. Associated with the flint implements, are vessels of earthenware of a rude and simple description. The skeletons found in these earlier graves have served to convince Canon Greenwell that they belonged to a peaceable and well-disposed people, inclined to agricultural pursuits, and living mostly on the results of

such pursuits; varied by an occasional animal caught in the thick forests which extended over the swampy vale of Holderness. These early inhabitants are distinguished from a succeeding people by their smaller stature, and the elongation of the head from the front backwards; by the softer contour of the facial angles, and by a general outline that must have been of a type at once regular and capable of considerable beauty. The later people who appear to have introduced articles fashioned in bronze into Yorkshire were of a larger, stronger, and more rugged character; their skulls were of a shorter and rounder form; and prominent cheek bones, eyebrows and jaws gave them a less pleasing expression, and indicate a more aggressive and fierce type of man. The incursion of the latter, probably from some part of the Continent on the opposite shores of the North Sea, was anything but an unmitigated good to the earlier inhabitants, and the result appears to have been that they were subjugated, perhaps reduced to bondage; their women were taken by the invaders, and gradually they and their works disappeared, absorbed by the victorious hordes of the invaders. The great series of mounds and earthworks which extend like a network from Flamborough Head, westwards over the wolds, were in all probability erected by the later people. They were possessed of much greater knowledge than their predecessors; and the fragments of linen and woollen fabrics found in their graves, together with pottery of an advanced type, and rings and beads used for ornament, prove that they were in possession of many refinements which were unknown in Yorkshire before their advent.

Implements of flint have also been found in the lake-dwellings at Ulrome, and in the kitchen-middens in the neighbourhood of Kilnsey and Spurn. These present features more or less similar to those found in other districts of the East Riding, and in another place have been already described with some detail.

The area from which flint implements have been obtained has been greatly enlarged, they have been found not only in the East Riding, the chalk wolds of which, together with Flamborough Head, are replete with flint nodules, but in the high ground bordering the county westwards, where no flint occurs in the strata nearer than

the East Riding source, large numbers of flints have been found, some of exquisite workmanship. In 1882, Messrs. Law & Horsfall* read a paper "On the discovery of flint implements on the hills between Todmorden and Marsden." The flints have been found in numerous localities mostly on or near the summits of the highest and most prominent hills on the Penine range. They are usually found beneath the peat and peaty subsoil, in a layer of sand with angular fragments of sandstone. The peat varies from a few inches to a very considerable thickness, and in several instances flint weapons have been found under 7 to 10 feet of peat. The flints are largely composed of chippings and flakes, together with occasional cores from which the flakes appear to have been struck off. Beautifully chipped arrow-heads and other objects are interspersed in smaller numbers. Scrapers, knives, and some exquisitely-fashioned small implements which may have been used as prickers to bore holes through hides or skins. On March Hill, a conical eminence overlooking the vale of Marsden, more than 2,000 flint objects were discovered, and hundreds of others have been found on the neighbouring heights.

The occurrence of flint implements in the western parts of the county is of wide extent; numerous flakes, arrow-heads, and other objects have been discovered on the hills in the neighbourhood of Sheffield in the south; and the moorlands north of Halifax, extending towards Haworth, have also been productive. In fact, on almost every hill where the peat has been removed, either by fire, denudation, or by human agency for fuel, and the stratum of sandy clay exposed at its base, diligent search has been rewarded by the discovery of flints in greater or less profusion on some part of its surface. At the base, or in the lower beds of peat, there are numerous roots and stumps of trees, sometimes of large size; they all terminate a few feet from the ground, and often several feet below the present surface of the peat. On many of the stumps there is evidence of fire, and the forest may, centuries ago, have been burnt down to dislodge a foe, perhaps the user of the flints now occurring on the surface, which was once that of the soil in which the trees grew and flourished. The

* Proceedings of the Yorksh. Geol. and Polyt. Society, vol. viii., p. 70.

peat is frequently 8 or 10 feet in thickness, and occasionally attains a depth of 12 or 15 feet, and there is little doubt that its accumulation has occupied a long period of years. When the Romans occupied this country, and had their seat of government at York, in the early centuries of the Christian era, the character of the country was much as it is now, and the Roman centurian in his ride from Eboracum to Mancunium, would find the transit across the Penine chain as dreary and as cheerless as his modern representative of a more peaceful calling, the manufacturer of forty or fifty years ago, who periodically crossed the hills in all kinds of weather, with a packhorse which carried the result of a week's labour, to be sold on the other side.

Whether the people who used the flint arrow-heads and left them in the sandy substratum existed and migrated beneath the branches of the trees whose bases still exist, it is impossible to say, but there can be little doubt, that if not living beneath their shadow, the men were anterior to the trees. The large extent in area over which the flint implements have been found, is evidence that the population must have been comparatively large, but much additional information must be obtained before anything more than the merest surmise can be ventured upon as to their state of barbarism, or whether these people, probably amongst the earliest of which there is any record in the county, were even at this early date in possession of some of the rudiments of civilization, and enjoyed some of the comforts of house and co-operation, resulting from the accumulated experience of a still more remote ancestry. It is a subject for speculation whether the inhabitants of the hilly country between Yorkshire and Lancashire had any relationship with the earlier tribes who inhabited the caves further north. In the Victoria cave, near Settle, flint implements have been found beneath stalagmite and clay, which indicate a very early type of man who lived ages before the Roman era ; and in Wensleydale and other parts of the North Riding similar remains of a prehistoric man exists, who appears mainly to have sought refuge and shelter in caves. There is no tangible evidence that the cave men and the hill men were contemporaneous, only a few fragments of flint, a cut and pointed bone, or a fragment of bone carved to form a rude adornment for some native beauty, or perhaps

to lend dignity to the chief of the tribe, are all that remains of the cave men, and of the others there is not so much.

Flint implements have been divided into two groups representing an earlier and later people, the former are distinguished as Palæolithic and the latter as Neolithic. In Yorkshire there is no positive evidence of man's existence during the Palæolithic stone period. But in the more southerly districts of England, numerous flints have been obtained from the river gravels at depths varying from 8 to 20 feet, which are of very great age, as compared with the Neolithic remains of Yorkshire. The earliest implements are usually of large size, and generally more or less abraded by the action of water, more or less club-shaped in form, rudely worked, often covered with an ocherous coating in the lowest or oldest beds, and exhibiting a lustrous surface when obtained from the strata at a higher level. The older and larger Palæolithic implements were probably held in the hand, "as one would now hold a heavy stone for smashing."* The rounded blunt end might be used as a hammer, whilst by reversing the hold on the implement, the pointed end could be used as a weapon against the wild animals or other foes. In the higher strata the implements found are smaller, and appear to be adapted for attachment to sticks sq so to form spears or javelins. The later Palæolithic men were capable of making much finer and superior objects to their predecessors. They had probably acquired a knowledge of dressing skins, and clothed themselves to some extent. They formed large colonies on the banks of the rivers, and their implements are found in large numbers near the course of the stream. This country was then united with the Continent of Europe, and a great part of the English Channel and the German Ocean were above the sea, and clothed with great forests, in which the mammoth, rhinoceros, hippopotamus, the horse, bison, reindeer, and the lion, bear, and other animals travelled and crossed to this country; their remains are found associated with the implements of men in the southern counties.

Besides the old river gravel remains, there are others of Palæolithic man which have been found in caves. The oldest flint implements found in caves in Yorkshire, are those from the Victoria

* W. G. Smith. Trans. of the Essex Field Club. Vol. iii., p. 123.

Cave, near Settle, but they are all neolithic. A bone was found at a much lower depth in the cave, associated with bones and teeth of hyena and other animals which the hyenas had devoured; this bone was considered by some authorities to be human. If this problematical evidence should prove to be correct, it will take man in Yorkshire to the Palæolithic age. The investigations conducted by Mr. W. Pengelly, F.R.S., at Kent's Cavern, near Torquay, have rendered available a large amount of information respecting the Palæolithic cave men. The lowest layer consisted of a breccia of sub-angular and rounded fragments of grit rock and contained bones of bear, fragments of jaws of lion with teeth, remains of fox and other animals, together with rude massive flint tools: above the breccia with remains of bear, is a thick bed of crystalline stalagmite, followed by a deposit of red clay with fragments of limestone, which Mr. Pengelly termed "cave-earth;" the cave-earth is full of bones of a large number of animals, including the cave hyena and lion, wild cat, wolf, fox, bear, mammoth, woolly rhinoceros, horse, deer, voles, &c.; amongst the bones were flint implements, a stone hammer, a bone pin and harpoon, evidence of the existence of man at the same period. The cave-earth was succeeded by a black layer of charcoal about four inches in thickness, the product of the fires of the cave-men who had occupied the cave after the hyenas had been dislodged. Great numbers of flint implements and burnt bones were found in this layer, as well as some implements of bone. Then follows 60 inches of stalagmite and another layer of black earth, in which are remains of the Romano-Celtic races, similar to the layer of black earth and charcoal found near the surface of the Victoria Cave. The age of the older deposits in the cave are variously estimated and depend mostly on the rate at which stalagmite is formed. Mr. Pengelly estimates that at the rate of 1 inch of stalagmite in a thousand years the 60 inches between the Celtic and cave-men occupations, would occupy 60,000 years in formation. Such a computation, however, is obviously dependent on an assumption which may be entirely without foundation, because the rate at which stalagmite is deposited depends on the amount of carbonic anhydride in the water which permeates the limestone rock, and the consequent amount of lime

dissolved and re-deposited, and this may vary very much in different localities and at different times. There can, however, be no doubt that the time taken to form these thick deposits of stalagmite must indicate a very long interval between the two occupations, compared with which the historical period is a small item. Beyond the black earth there is the period during which the cave-earth was formed, and man shared occupation of the cave at intervals with the hyena; and beyond that again, a thick bed of stalagmite and then the flint weapons amongst the remains of the bear. A period many thousands of years in extent is absolutely indicated by the successive series of remains; and the oldest of them much more recent than the earliest remains of man in the river-gravels. Even in the latter, the most antiquated members of the human species were possessed of considerable intelligence, they fashioned tools and weapons, lived in communities and no doubt combined for purposes of offence and defence. It is necessary to go further back still for evidences of the earliest men, and it is not probable that they will be found in such an inhospitable climate as that of this country, but rather in the warm and sunny lands to the south and east.

Having recorded the principal instances in which flint implements have been found, it is proposed to consider the probable condition of the people who used them. It has already been shown how meagre is the information that can be deduced from the objects taken in the abstract as they are found, and it is only by inference that we can ascertain the method of their living and the probable aims of their existence, by instituting a comparison with the people of those countries, still in a primitive state of existence, who manufacture and utilize weapons and other objects made from flint, obsidian, or some other stone. It is possible that one of the scientific aims of the present age, which will be considered most favourably by future generations, will be the vast stores of information which have been accumulated respecting the primitive condition of the human race, whether the matter be considered from the standpoint of an evolutionist and the development of the species from inferior animals, as embodied in the writings of Darwin and Huxley; or the scarcely less important bearings of the discoveries throughout all

parts of the world, having relation to prehistoric man, his manners, his customs, and the influence his existence has had in the general progress of the species.

Mr. E. T. Hardman,* who was a member of the Geological Survey of Ireland, and afterwards spent some years in Australia to prepare a Report on the Geology and Mineralogy of Western Australia, had many opportunities to study the natives in the district around Kimberley. He examined their implements of warfare, and learnt the uses and mode of manufacture of the flint, stone, agate, trap-rock, or other hard materials. They strikingly resembled those obtained from the ancient barrows and kitchen-middens of this country. The stone implements in Australia are almost entirely restricted to the northern part of the continent, and are rarely found in the south. They consist of spear-heads, celts or hatchets and small chisels, similar to the objects termed scrapers in this country. In the north of Australia there are extensive deposits of flint and jasper, as well as of agates, and in the river beds large pebbles of pure rock crystal. The sites of manufactories of implements are denoted by the quantities of flint flakes lying about From the rock crystal very beautiful spear-heads are made, as well as knives used in the operation of circumcision and other similar rites. The progress of civilization has introduced another material which the natives have not been slow to utilize, and many of their weapons are now made from glass bottles. Leaf-shaped spear (or arrow) heads are made about two inches in length, finely pointed, with serrated edges. They are attached to sticks and used chiefly as projectiles. being thrown from the hand, assisted by a throwing-stick, at the end of which there is a hook to be inserted into the butt of the spear; its action, in giving considerable velocity, resembles that of a primitive bow. They are also used for throwing javelins.

Mr. Hardman gives the following description of the method of fabricating implements, which appears so interesting as to necessitate its being given in his own words:—"I induced a native to show me the process on a portion of a broken bottle. Knocking off a piece of a suitable size, he then procured a rounded sandstone

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* Journ. of the R. Hist. and Archæol. Assoc. of Ireland, vol. viii. Fourth series, p. 90.

pebble, which he slightly rubbed on another stone to give it a bite or tooth; and the next requisite was a small piece of wood. Now seating himself he placed the wood beneath his toes, with the glass resting edgeways on it, between his first and second toes; with light blows, adapted to the nature of the flake he wished to strike off, he then deftly chipped the glass into its first rude leaf-shaped form; this being accomplished lighter blows were given, until a certain amount of finish was obtained. Then, by slight taps from a small and flat-edged stone, the fine point, and the finely-serrated edge, were gradually formed. The whole operation did not occupy more than half-an-hour, and the specimens are rude in appearance, having been made hurriedly in order to explain the process. Still it is wonderful that a material so brittle and treacherous as glass could be worked into this form by such simple means." The hammer stones found on the wolds appear to be very similar to those used by the Australians in the manufacture of their implements, and Dr. Evans has pointed out that flakes may be produced from a flint nodule by means of a rounded pebble used as a hammer, simply held in the hand. The spear heads are attached to shafts several feet in length, composed of heavy acacia wood in the upper half, the lower being made from bamboo. The flint or glass head is attached by means of a tenaceous cement, a gummy substance which exudes from a grass and is gathered for the purpose. It is soft when warmed, but on cooling the spear head remains firmly fixed.

The Australians use stone hatchets very similar in form to those found in Yorkshire. They are manufactured in the same way as the flints, and then undergo a further process of grinding to a smoother edge. They do not appear to be used in warfare, but for the purpose of cutting wood to various uses. The manner of fixing the head is peculiarly simple and interesting. A slip of acacia wood, about the diameter and thickness of a barrel hoop, is doubled by the aid of heat into a loop, and in this loop the hatchet is fixed with spinifex gum; the two sides of the handle are then brought together, and fastened firmly with ligatures of kangaroo sinew, the length of the handle being usually 16 or 18 inches. The stone chisels, which greatly resemble the implements supposed to have been used for dressing

skins, are tied in the end of a piece of stick and used for marking their shields or other wooden objects. They never use them for dressing skins, because they go absolutely naked. The various tribes carry on a good deal of barter, and frequently exchange with others at a distance of a hundred miles or more, not only implements and gums, but also red ochre and white pipe-clay for the ornamentation of their bodies.

Interesting accounts of the methods employed by the Mexicans have been given by Torquemada and Motolinia, and more recently a communication was made by Mr. Sellers,* giving his experience on the banks of the Saline River. He found a few miles above its junction with the Ohio, that the land on the banks of the river extended for some distance quite flat, and when these lands were cleared of wood and the plough had loosened the surface soil, it was not an uncommon occurrence during periods of great flooding from the river, for 2 or 3 feet of the surface soil to be washed away from large areas and leave the remains of ancient flint or stone workshops exposed. Cores and waste chips were abundant, and from a careful examination of these, together with a vast accumulation of finished and unfinished implements and tools, Mr. Sellers was able to deduce a tolerably succinct idea of the method of working pursued. The most abundant material was chert from the mountain limestone. Flint is very rare in America, from the fact that it does not occur in the strata. Jasper, chalcedony, and agates are also used, and have been principally obtained from the beds of the rivers. Considerable information was derived by the author from Mr. Catlin, who devoted many years of his life to painting portraits of Indians, which are now in the National Museum. During his sojourn amongst the Indians for this purpose, he had opportunities to study the way in which they make their implements. Most of the tribes had men who were expert at flaking and possessed a knowledge of the character of the material used, which enabled them to proceed directly to the best mode of working. The tools used consisted of a piece of pointed bone or buck-horn inserted in the end of shaft of wood, 3 or 4 feet in length, and 2 or

* Smithsonian Report, 1885. Pt. I., p. 871. Observations on Stone-chipping, by G. E. Sellers.

3 inches thick. The end of the shaft was bound with sinews or thongs of raw hide, to prevent its splitting. Across the upper end of the shaft was a transverse piece, against which the chest could be placed to give greater impulse to the pressure in using the implement. Obsidian, and the more easily flaked stones were placed between the feet, harder stones were partially imbedded in hard earth. A small indentation having been made on the block, the tool was placed in it and a sharp impulsive pressure given to it, and a flake was separated. Where large and massive flakes are required and the strength of a man was insufficient to throw it off, an instrument similar to the one already described was used, except that in selecting the staff care was taken to secure the trunk of a young tree with a branching stem at a few inches from the bottom. The latter was cut off at a few inches from the main trunk, so as to form a notch, and whilst the pressure was applied by the individual holding it, a second man gave a smart blow with a hammer in the notch. This combination of impulsive pressure and the percussion of the blow rarely failed to throw off the flake, sometimes 10 or 12 inches in length. Where the best beds of chert occur intercalated with the limestone of the coal measures, the manufacture of stone implements found employment for many of the Indians. One set dug out and selected the chert in the quarry. Others prepared the blocks for the flaker, whose operations are described above, and succeeding workers took the flakes and manufactured them into spear or arrow-heads, and such other tools or implements as were in request. As already mentioned with regard to the aborigines of Australia, the implements in America formed a staple article for barter and exchange. The flake was first attacked on the flat surface, that is, the one which had been separated last from the nucleus or core, and its edges reduced to something like the form of the object to be made, say the head of an arrow ; the opposite surface was next dealt with, a second series of pushes produced a line of fractures extending over the surface and leaving a serrated margin to the implement, repeated and more delicate operations gradually evolved the perfect arrow-head. A large variety of objects were thus made from the delicate drill or arrow-point to agricultural implements made from quartzite or chert, which are 12 to 16 inches in length,

and 6 or 7 inches in width. The manufacture of such large objects from so intractable a material is evidence of a very high degree of skill and intelligence. The working tools of the Indians are, or rather were, valued beyond all price, and nothing would induce them to part with a good flaking tool. Now, however, they are rapidly becoming a thing of the past, and the art a lost one; the rifle is taking the place of the bow and arrow. For boys' practise, and for small game, the iron points got from the fur traders are preferred to stone. A common jack-knife is worth more to them than all the flint knives and saws ever made. Just in the same way the Birmingham brass battered-ware kettles, the Yankee tin-ware, and glass whiskey bottles have almost totally destroyed their crude art of pottery making.*

Sir John Lubbock, in "Pre-historic Times," states that whilst scrapers of stone or flint appear to have been universally used in Europe for the preparation of skins for wearing apparel, in North America, south of the Eskimo region, they are very rare, if they occur at all. Mr. Sellers found objects used as scrapers very abundant and remarks: "I think it most probable from their close resemblance to refuse flakes and chips, they were overlooked by early collectors. In the great game districts of the west, both in flint workshops and among the waste of the Indian settlements, they are much more abundant than arrow-heads, or any other implements, with the exception of small flint knives."

The method of manufacture practised by the North American Indians as described above is sufficiently distinct from that of the aboriginal Australians. Both are of sufficient interest to be worthy of record, and either may have been practised by the early natives of this country.

The earliest races of men in Yorkshire are probably still unknown, and as already observed, future discoveries may disclose some facts which shall reveal the primitive inhabitants who preceded the oldest flint users of whom we have such records as have been considered in the foregoing pages. Of the characteristics of those of whom we have so slight traces only guesses can be made. The earliest inhabitants of the county were probably cave dwellers, and perhaps contemporary with them the nomadic tribes who have left their implements

* **Catlin. Smithsonian Report, 1885. Pt. I., p. 874.**

scattered over the Penine chain of hills. On the east coast, near what is now Spurn point, and occupying an area at one time extending far into the North Sea, but now swept away and enveloped in its waters, were tribes of men who dug large hollow pits in which they deposited their refuse. Others further north in Holderness erected dwellings over the lake-like meres which covered a large portion of its surface, whilst probably at the same period the mound and entrenchment builders covered the higher ground of the chalk wolds. Whether they preceded or succeeded the kitchen-midden people is uncertain, but we do know that long ages before either existed, a people lived on the banks of the rivers in the South of England, who were contemporary with animals long ago extinct in this country, when England formed a part of the Continent of Europe. What physical conditions prevented their migration northwards to Yorkshire, or if they did so, what has become of the evidence of their occupation, are questions which must remain for the present unsolved.

The age of the early tribes of mankind is a subject which always excites interest, and interesting speculations on the subject have been formulated in every country where the study of pre-historic man has been made. That man as a species ranges far back into geological time, there can be little doubt. The recent researches of anthropologists, both in Europe and America, appear to indicate a common origin in some warm and hospitable climate, probably in Asia, for the several branches of the human race. In Europe successive migrations have tended westwards, whilst American investigators find that the primitive population travelled eastwards, probably crossing from Asia in the first instance by way of Behring Straits. In considering such early migrations, it is always necessary to bear in mind that the present level of the sea and land is not fixed, and that in the dim past when the earliest men were gradually extending over the surface of the globe, the relative positions of land and sea may have been very different.

The state of culture and the progress towards civilization amongst the different races of men has been very unequal in different localities, and whilst some nations have progressed, others bound down by adverse circumstances and inhospitable climate, have persisted in

savagery to the present time. Such circumstances exist in the far cold north, or in arid districts of Western Australia, and the still more dreadful districts of Terra-del-Fuego. In the two latter, old and useless members of the community are killed and eaten in times of scarcity. The greatest cruelty prevails, and wild superstitions cause the natives unutterable terrors.* The primitive man was a slave to nature; in continual terror before dangers which he did not understand, and could not guard against. Nature to him was an appalling mystery out of whose bowels anything might issue. He lived in a haze of fetichism. Not a leaf might flutter, not an animal cross the path, no distant thunder roll, or raven croak unseen, but heralded to him some spirit only too malign. Those who have observed in a distant camp or remote village of savages the midnight alarms, the whispered fears, the wild unfounded rumours, the cowering before the most simple physical phenomena if only unfrequent—only those can have a realizing sense of the horrors nature unfolds for the ignorant yet thinking savage. To what extent the ancient savages who occupied the hills and dales of Yorkshire resembled their existing representatives in these distant parts of the world we do not know; but, for the credit of the county, let us hope only to a small one. That the struggle for a living was a severe one there can be little doubt, but that the naturul produce of the soil, and of the rivers and sea was probably sufficiently abundant to render unnecessary, except under very rare circumstances, a resort to cannibalism may be reasonably inferred.

NOTE ON THE OCCURRENCE OF LINGULA IN THE MILLSTONE GRIT SERIES, WEST OF RIPON. BY REV. J. STANLEY TUTE, B.A.

During the excavations in making reservoirs for new water works for Ripon, on Lumley Moor, about seven miles west of that city, a bed of black shale was exposed intercalated with others. It is difficult to fix the exact horizon of these shales, but they seem to be those which occur below the Follifoot grit. In the black shale was discovered examples of Lingula, which have been identified by Mr. R. Etheredge, F.R.S, as *Lingula credneri*, or *L. mytiloides.* This discovery is interesting, being the first recorded from the Millstone grit strata of this district.

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* Pre-historic America. Nadaillac 1885 p. 521.

ON THE BRONZE IMPLEMENTS FOUND IN THE EAST RIDING OF YORKSHIRE. BY THOMAS BOYNTON, ESQ.

(Prepared for the British Association Report on the Evidences of Pre-historic Inhabitants of Great Britain.)

N.B.—The numbers in the first column refer to the illustrations in Dr. Evans' "Bronze Implements of Great Britain."

Type.	Name of Object.	Locality.	Date.	Previous Description.	Where Deposited.	Length.	Remarks.
16	Celt - -	Staxton -	1886	—	Own Collection	$4\frac{5}{8}$ in.	Has ten waves on the blade and cable pattern on flanges.
12	,, - -	Driffield -	—	—	,,	$3\frac{1}{2}$ in.	The flanges are very slightly raised, and it has not the fluted pattern as described in Evans.
53	,, - -	Gransmoor -	1862	—	,,	$7\frac{1}{8}$ in.	Weight 21 oz.
50	,, - -	Ulrome -	1879	—	,,	$5\frac{3}{4}$ in.	Has very slight stop ridge and plain blade
55	,, - -	,,	—	—	,,	$5\frac{1}{4}$ in.	
56	,, - -	Kilham -	1882	—	,,	$5\frac{3}{8}$ in.	There is a slight vertical ridge on the lower part of the blade.
76	Palstave -	Leven -	—	—	,,	$5\frac{1}{4}$ in,	Pocketed at the stop ridge $\frac{1}{2}$ in. deep.
55	Celt - -	Barmston -	1881	—	,,	$4\frac{1}{4}$ in.	The edge has been hammered out.
120	Socketed Celt	Leven -	—	—		4 in.	Rim imperfect.
116	,,	Gainsboro' -	—	—	,,	$4\frac{1}{3}$ in.	
164	,,	,,	—	—	,,	$3\frac{3}{4}$ in.	
169	,,	Harpham -	1876	—	,,	3 in.	
125	,,	Hutton-Hang	—	—	,,	$3\frac{1}{8}$ in.	
125	,,	Ulrome -	1877	—	,,	3 in.	
136	,,	Skipsea - Brough	1885	—	,,	$4\frac{3}{4}$ in.	The chevron pattern is much closer than the Winwick specimen, and it has 4 horizontal lines on each side, like 138, Evans' 'Ancient Bronze Implements of Great Britain.'
398	Spear-head -	Ulrome -	1860	—	,,	$4\frac{1}{8}$ in.	
394	,,	,, -	,,	—	,,	$6\frac{3}{4}$ in.	
405	,,	Brigham -	1880	Evans, 'Br. Impts.,' p. 327	,,	$6\frac{3}{4}$ in,	Dr. Evans has erroneously described this as found near Lowthorpe.
382	,,	Leven -	1885	—	,,	$7\frac{1}{2}$ in.	Imperfect, the socket being broken.
395	,,	Skipsea -	1880	—	,,	$4\frac{3}{4}$ in.	A portion of the shaft still in the socket.
401	,,	Carnaby -	—	—	,	$5\frac{1}{3}$ in.	There are traces of ornamentation on the socket, probably done with a chisel or punch. Unfortunately the boy who found it struck it against his plough and broke the point.

Type.	Name of Object.	Locality.	Date.	Previous Description.	Where Deposited.	Length.	Remarks.
386		Lake-dwelling, Ulrome	1882	—	,,	4½ in.	Appeared to have been struck into the floor of the structure and broken from the shaft; a portion of the shaft (with the pin) yet remains in it. Caught by the workman's spade and broken.
114	Socketed Celt	Barmston -	1886	—	,,	2½ in.	Found embedded in peat near the supposed site of a lake-dwelling. The top of the socket has been imperfectly cast, and it is filled with fragments of metal preparatory to re-casting.
499	Button -	Near Beverley	—	—	,,	1 in. diam.	The loop spans the entire diameter, and is bow shaped. Plain, increasing in thickness downwards; circular.
—	Ear-ring -	North Burton	1876	—	,,	—	—
—	Bracelet -	Near Beverley	—	—	,,	—	The bracelets are made of wire, plaited, and were purchased from Mr. Sumner's collection, Woodmansey, Beverley, described as being found in the locality.
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NOTES ON DISCOVERIES OF BRONZE IMPLEMENTS, ETC., IN THE WEST RIDING. BY JOHN HOLMES, ESQ.

I assume that objects of known Roman make, either in pottery or metal, will not be deemed pre-historic, although made or used before being registered in historic times. But I think that objects evidently native or British may be classed as pre-historic, even when used by the Romans or in historic times, with that understanding I place first from Thoresby's Ducatus Leodiensis, p. 565, the discovery of a British urn, 10 inches in diameter, in which was "a brass lance, a stone to sharpen it, and a mallet's head, of spreckled marble, polished 6 inches in length, 3½ broad, and 7 in circumference. It was discovered in the field of Stephen Tempest, of Broughton, Esq." Thoresby describes it as very artificially done, as if it had been a Roman improvement of British work. For his desertation and further suppositions see Ducatus, p. 566. The lance he describes as of brass, scarce an inch broad, and by its tapering 3 inches long, sharp enough

to shave a solemn priest. The stone is of blueish grey stone, scarce an inch in thickness, though three long. There were also certain bone instruments mostly decayed to ashes, the ends of which were bored through the same size of holes as the lance and stone are. Use unknown, tapering like a bodkin to the end quarter of an inch. For some further but uncertain discoveries and objects see p. 567. For such objects and there bearing see Evan's Stone Implements, pp. 173, 187, &c. &c.

For a somewhat similar discovery, James Wardle, Deputy Town Clerk, Leeds, registers that of a British urn in 1745, dug up in a field at the top of Briggate, Leeds, about 2 feet deep. It contained calcined bones and a stone hammer (size and weight not given), but fortunately drawings were preserved, and figured by Wardell in his Antiquities of Leeds, 1853, plate 1. The urn was of rude formation, and imperfectly buried, ornamented in the usual British manner with encircling rows of indentations. The urn was about 12 inches in height, mouth upward, covered by a stone. The whole taken possession of by Ald. Denison, the owner of the field, and now completely lost.

The urn appears in both shape, size, and ornamentation to be not uncommon in Yorkshire, and the hammer is similar to two others, which Mr. Wardell had in his collection, which I purchased in 1860, and transferred to the Corporation of Leeds, 1882.

In the year 1709 Thoresby registers "the digging up of five or six brass instruments ploughed up in Bramham moor by the servants of John Ellis, of Kidd, Esq. They are of different sizes, from little more than 3 to 4½ inches in length, and from 1 to 2½ in breadth. They are somewhat in form of a wedge, from a thin sharp edge to 1½ or 2 inches at the thicker end, where they are hollowed to put upon a shaft, each having an ear or loop." This is a common form of bronze socketed celt, of which I transferred several to the Leeds public collection.

Thoresby also figures another and earlier (?) form of bronze celt, dug up in the grounds of Ambrose Pudsey, of Bolton juxta Bolland, Esq., whilst making a fence near the moor, now called Monnebents. This is 7 inches long and 2¾ broad at the edge, which is placed

foremost for execution, and is yet sharp and piercing. A wooden stem was fitted into a hollow on each side of it. See Ducatus, p. 565. Several similar are in my collection found near Leeds, Morley, &c.

Thoresby also figures a flint arrow-head of the ordinary size, barbed and tanged edges being serrated, and a spear-head which he figures about 2 inches long smoothe. He says the latter was dug up in a field besides Adel Mill, a Roman station. His tendency was to attribute all these to Roman times and uses.

Thoresby figures a shield (which I think to be British) as Roman, with a good description of its construction; but giving neither time nor place of discovery, p. 565. (Very similar have been found in the Thames).

In 1776, continuing somewhat in the order of time, I direct attention to the remarkable find on Mixenden Moor, near Halifax, given by Whitaker, in his Loides and Elmete, p. 373. The plate showing the celts is an exquisite production of art, but that such a collection could be found altogether as described is utterly incredible. For granting that which he calls the hone or whetstone and beautiful brass celt may be with the gouge British, the maul, and the three arrow-heads are Canadian. Whitaker appears to have had them in 1816. What has become of them, or where and what they are is deserving of more than usual attention.

For a find of British sepulchural urns, near Halifax, see "The Remains of Antiquity of Yorkshire," Leeds, 1855, p. 26, by F. A. Leyland, of Halifax, who may be still referred to. In the same work, see account of a British Barrow and contents, by Mr. Proctor, of York, p. 38. Also, the discovery of a British Dagger and Boat, p. 39; and a British Barrow and contents, at Worsborough, by James Wardell, p. 57 and 75, I purchased the objects discovered about 1854, and they are now in the Leeds public museum. The discovery of bronze celts, p. 64. "Account of the discovery of British remains on Baildon Common," p. 87. This book is well worth examination, on account of its reports of pre-historic discoveries. In the Philosophical Hall Collection at Leeds, are several bronze celts found in Yorkshire. One well-formed basalt celt is given as found in School Close. In 1870, while forming the North-Eastern Station at the top of School

Close, when crossing the course of the River Aire, the workmen uncovered a series of black oak piles deep in the river bed, and a workman found a stone object 3 in. long, 2½ in. broad. It looks like an Irish lake net sinker, formed from a used up hammer. For a further account of finds of bronze celts, see a paper published by the Yorkshire Geological and Polytechnical Society, 1881.

About 1870 a well-formed stag-horn pick-axe was dug up in Grove-road, Ilkley, about 15 feet deep. This has similar features showing use to those found by Canon Greenwell at Grime's Graves, Norfolk.

About that time Mr. Joseph Lund, digging in his garden, on the edge of the moor, turned up a well-formed thumb-flint, about 1½ in. diameter. It is round and finely flaked at the edge. A similar one was found by Mr. Dresser in his garden at Adel. Both are perfect. Flint flakes are not uncommon upon Ilkley moor, but arrow-head and other forms though occasionally found are very rare. Mr. F. W. Fison, of Ilkley, has a small collection. Flint is not native at either Adel or Ilkley. The wolds, some 50 or 60 miles off, are the nearest flint fields. At Adel, between 1865 and 1875, a large series of flint-flakes, well-formed arrow-heads, scrapers, and other implements were discovered at the Adel Reformatory by youths when "taking in" the rough moor land. Most of the articles went to the Leeds Philosophical Museum where they still are; I obtained some; among which, in 1878, was a well-defined core, a body from which flakes and arrow-heads were struck. These are in the Leeds Public Museum. The whole (?) of these flint finds at Adel centered about one high stone (still there), as though it were the workshop of the manipulators. This area being pretty well cleared of flint; few or none are now discovered.

From Rombalds Moor to Adel, and so on, east to the Vale of York, a line of high moorland runs to Moortown, Shadwell, and Barwick. Along this line a number of pre-historic discoveries may be registered within the last ten years. There in the February of 1879, a labourer ditching in a field between Potter-Newton and Meanwood, in a rather low clay bed, discovered a fine well-formed stone hammer head 8¾ inches long, 3½ thick, and 3¾ across head end, sloping gradually to the cutting edge. The hole drilled for the shaft is

$2\frac{3}{4}$ in. in width, and shows evidence of use at the cutting edge. This, with two others similar in shape, but rather shorter are in the Leeds public collection. Mr. Wardell obtained the two latter on the east coast, the granite one at Scarborough, and the other bassalt, out of Esk Dale, between 1850 and 1856.

About two miles east from the Shadwell Reformatory, a beautifully formed stone celt was turned up in ploughing about 1881-2. It was taken possession of by the governor ; when leaving he took it with him. It measures about 4 inches in length, was about 2 inches thick, had a round smooth cutting edge $2\frac{3}{4}$ inches across, and tapered wedge shape to the end. Similar forms are figured by Evans in Nos. 51, 52, 53, 55, and 57, varying in size and thickness. In a line still east about a mile and a half from the Reformatory, on the Roundhay Park estate of the Leeds Corporation about 1880, a good form of the bronze socketed and looped celt was found. Very similar in shape and ornament to those figured by Evans, Nos. 134, 166, &c.

Again, about a mile and a half, while forming the front garden to the beautiful villa of Woodburn, belonging to R. Buckton, Esq., in 1884, the same gardener who discovered the last, dug up a beautiful stone celt, of exactly the same form and type as the one in the collection of the governor. It is beautifully and symmetrically formed, but at opposite edges about $2\frac{1}{2}$ from cutting edge, and $1\frac{1}{2}$ from end, it I think shows sign of wedging. It is in the possession of Master Buckton to-day.

In February of 1887, I obtained a stone celt, $4\frac{1}{2}$ in. long, and 8 oz. in weight, the form, size, and type of the Nos. 18 and 20, bearing the following label :—"Early British axe-head found at Potterton, near Leeds, volcanic stone from North of Scotland, over a thousand years old. (Signed) Charles Richardson." Potterton is a little hamlet near to Barwick-in-Elmete, and is about four miles east from Roundhay, in a line with the three preceding finds, and being about a mile east of the bronze find upon Bramham Moor, as before said, the whole are in a line from Skipton to Ilkley, Adel to Wetherby, and Tadcaster and York. In this line, from Yeadon a decayed bronze celt was exhibited at a local exhibition at Bradford, 1882. I have heard of no other bronze being found west of Yeadon. At Yeadon at a place

called Billing a gold torque was found, registered by Mr. Denny in the Leeds Geological and Polytechnic Society's transactions. It went to the British Museum.

In a field at the base of Sandall Castle a beautifully-formed wedge bronze celt was dug up about 1855. It measures 4 inch in length, has a good cutting edge, is slightly flanged, and is well patinated. This with the Woodnook dagger, and the Leeds, Hunslet, Churwell, and Beeston finds would extend or widen the line or belt from west to east by about three miles at Leeds, and five at Sandall. The finds from Hunslet and Beeston appear to be along an ancient track. The preceding I believe to be all British, but it is due to state that in this belt a considerable number of Roman remains have been dug up, to wit, Roman stone altars at Chapeltown Church, and at the front of Mr. Kitson's Entrance-hall, Roundhay, 1880-1. A fine Roman lamp was picked up by Mr. Marles in the Gorge of Roundhay Park, which he sold. and it is lost. A Roman house with good tesselated pavement was dug up at Shadwell, on the line of the Roman road, (Street lane between Adel and Wetherby), which is now in the museum at York, but is not pre-historic.

In the last thirty years the Rev. Richard Burrell, of Stanley Church, near Wakefield, has obtained a number of flint flakes, scrapers, arrows, and other flint implements from the ploughed fields of Stanley Ferry. They are found on the hills, the valley being evidently a lake in historic periods, in which the finds of a British tree-boat, and the finest bronze dagger that I have ever seen were made. See description and cuts, p. 39, "Remains of Antiquity in Yorkshire, Leeds, 1855."

Mr. Burrell obtained from a gravel hill in Mr. C[illegible]'s park, Oulton, an undoubted British food vessel fr[illegible] It is pierced at the sides.

ON PHOTOGRAPH OF CLIFF-SECTION AT HILDERTHORPE.

BY G. W. LAMPLUGH.

List of some works in which the section has been described, or referred to :—

1. Phillips, J. 'Geology of Yorkshire.' 3rd ed. Part I., p. 82.
2. Dakyns, J. R. 'Glacial Beds at Bridlington,' in Proc. Yorkshire Geol. and Polyt. Soc. Vol. VII. Pt. II. (1879), pp. 125, 126.
3. Lamplugh, G. W. 'Glacial Sections, Pt. II.,' in Proc. Yorks. Geol. and P. Soc. Vol. VIII. Pt. I. (1882), pp. 27 to 38, with drawings.
4. Lamplugh, G. W. 'Glacial Sections. Pt. III.,' in Proc. Yorks. Geol. and P. Soc. Vol. VIII. Pt. II. (1883), p. 241 and 251.
5. Dakyns, J. R. and Fox-Strangways, C. — Survey Memoir 'The Geology of Bridlington Bay' (1885), p. 10.
6. Reid, Clement. Survey Memoir. 'The Geology of Holderness' (1885), p. 73.

The photograph issued with this year's proceedings is of a fine section in cross-bedded laminated sands and sandy clays in the cliff at Hilderthorpe, near Bridlington Quay.

The place is about 300 yards south of Bridlington Harbour, just beyond the sea defences, where there is an excavation for sand at the top of the cliff, as shown in the upper right-hand corner of the photograph. The height of the cliff at this point is about 45 feet, but a short distance to the right there is a rather sudden fall of the ground to about 20 feet, whereupon the character of the section changes entirely (as may be seen on referring to the paper No. 3 of the above list).

The sea is encroaching very rapidly upon this part of the coast line, the loss between the years 1872 and 1882 having been at the average rate of 15 feet per annum, and as the cliff wastes back the section is constantly undergoing slight changes.

At the head of these notes will be found a list of the papers known to me which refer to this section. The most detailed account is contained in my paper (No. 3 on the list) printed in these pro-

ceedings for 1882, which includes a drawing to scale and a description of the cliff-section for 910 yards, commencing at the harbour, and working southwards. If the folding-plate of that paper be referred to, the section shown in this photograph will be found about an inch to the left of the large reference letter C.

There is a few feet of boulder-clay—the "upper purple boulder-clay"—at the foot of the cliff, but this being covered with talus, especially on the left side of the photograph, is not well shown. Patches of talus also obscure the bedding of the sands here and there throughout.

Above the boulder-clay there is a rough irregular glacial gravel (not visible in the photograph) which is often curiously contorted and intermingled with the clay.

The rest of the section is composed of the finely-laminated "warps" and sands with a little small gravel, which stand out so well in the picture. It will be noticed how these beds curve over the boss of boulder-clay on the right-hand side of the picture, and in this way they often fill up irregularities in the surface of the lower beds. In some places they are beautifully ripple marked, but this, though it may be traced here and there, is not so well shown in this part of the section as elsewhere. Near the top of the cliff, especially on the left side, it will be seen that the beds are puckered and twisted as if by contortions. This disturbance is very peculiar, and Mr. Dakyns has suggested (*supra cit*) that it may in some cases be due to incipient concretionary action.

Careful search has failed to reveal any shells or other fossils in these beds, but on some of the laminæ there are curious pittings and markings that look somewhat as though they may have been made by living creatures.

For the whole of this laminated series I have suggested the name of the "Hilderthorpe Sands," and it is my opinion that these beds are of fresh water origin, and have been deposited in a shallow lake or estuary by the waters of a river coming down from the main wold valley, at a period closely following upon the retreat of the ice-sheet which spread out the boulder-clays.

ON THE FOSSIL FRUCTIFICATIONS OF THE YORKSHIRE COAL MEASURES.

BY WILLIAM CASH, F.G.S.

No. 1. CALAMOSTACHYS.

The fructifications of the fossil plants of the Coal Measures are of great interest to the botanist, whether studied from an evolutionary point of view, or simply as guides to the classification of the plant-remains with which they are usually found associated; and none of them are more interesting than the small cone-like fruit spikes so well known to palæobotanists by the generic name *Calamostachys*.

The coal-measures up to the present time have yielded to geologists no remains of plants referable to the large group of true flowering plants (Angiosperms), for the Scotch fossil *Pothocites grantoni*, which is often quoted in text books of geology as an example of a fossil dicotyledonous plant nearly allied to the recent arums, had its supposed systematic position questioned so long ago as the year 1874, by Professor W. C. Williamson, F.R.S., and his views have since been abundantly justified by the researches of Mr. Robert Kidston, F.G.S., who, with fuller material at his command has, in the Annals and Magazine of Natural History for May, 1883, demonstrated that *Pothocites* is the fruit of *Bornia* (*Archæocalamites*) *radiata*, Brogn., or of a closely allied species of the same genus.

With the exception of some spores and a few examples of the mycelium of a fungus, the whole of the carboniferous flora is probably restricted to what modern botanists call the *Archegoniatæ;* since, in the present state of knowledge, they may all be referred to either the vascular Cryptogams, or to the Gymnosperms.

Twenty-five years ago the fructifications of the coal flora were known, almost without exception, either as casts, by the impressions of plants from iron-stone nodules or from shales, or by still more imperfect examples found in the grits and sandstones.

During the last two decades, however, the exploration and study of the calcified fossils of the Halifax Hard Bed Coal in Yorkshire, of the

equivalent bed at Oldham and elsewhere in Lancashire, of the Scotch beds at Laggan Bay in the island of Arran, at Burntisland, in Fifeshire, of the coal measures of Westphalia, of Moravia, and of Barnat in S. Hungary, as well as of the silicified specimens from St. Autun and St. Etienne in France, have yielded rich and precious material, which has thrown a flood of light upon an exceedingly difficult department of palæobotany, for it was only when the delicate organs of fructification were discovered with their minutest structures intact that the consequent rapid advance in our knowledge of this department became possible.

In Yorkshire, through the energetic and intelligent labours of Messrs. Binns, Butterworth, and Spencer, many interesting forms have been discovered and described, and especially by the long-continued and invaluable researches of Dr. W. C. Williamson, has this department of palæobotany been again and again enriched.

The chief fossil fructifications of the Yorkshire coal measures are Lepidostrobi or fruit cones of Lepidodendron of several species, the true fructification of Calamities. (Williamson: Memoirs of the Literary and Phil. Society of Manchester, 1869-70.) Bowmanites (Volkmannia) Dawsoni, probably the fruit of Asterophyllites. (Williamson: Memoirs of the Literary and Phil. Society of Manchester, 1870-71.) Several sporangia of ferns, and the fruits of numerous Gymnospermous plants, (Cardiocarpon, Lagenostoma, Trigonocarpon, &c.) In addition to those now enumerated there are many sporecases, &c., (Sporocarpon, Traquaria, Zygosporites, &c.), which are as yet of doubtful affinities.

The state of preservation in which these fructifications occur is very remarkable, the cells of which the organisms are built up have been infiltrated with transparent carbonate of lime, the cell-walls have been mineralised, and when the fossils are found fairly free from iron pyrites, they may be cut by the aid of the lapidary's wheel into slices, which can be attached by canada balsam to slips of glass, and then ground down sufficiently thin and transparent for microscopic examination; under a low magnifying power they display all details as perfectly as sections cut from a living plant, and under the higher powers are seen to exhibit a perfection of structure even in their

minutest parts, which is not only highly instructive but also exceedingly beautiful to look upon; to quote the exclamation of the late Charles Darwin on his first acquaintance with these coal-plant micro-preparations, " It is marvellous to see structure so admirably preserved for so many ages."

The Yorkshire localities for these fossils with minute "structure so admirably preserved," are the pits where the "Halifax Hard Bed Coal" has been worked, these may be studied all along a line parallel with the outcrop of the lower coal-measures extending from north to south by Leeds, Yeadon, Denholme, Holmfield, Sowthowram, Halifax, Elland, Huddersfield, Hepworth, Penistone, and Hazlehead near Sheffield. A portion of the Lancashire bed known as the "Upper Foot Coal," occurs near Saddleworth, on the Lancashire border of the county.

The Hard Bed or Ganister coal may be readily recognised and traced over the whole coalfield, it lies on hard ganister underlying, which there is usually a bed of fire-clay ; the roof of the bed of coal is generally composed of a dark shale containing fossil shells (Goniatites Listeri, Orthoceras Stienhaueri, Aviculopecten papyraceus, and other marine shells.) The coal itself and the superimposed shales often contain calcareous nodules with included fossils, the nodules in the coal known locally as coal balls, generally contain plant remains with the minute structure sometimes beautifully preserved but often, alas ! spoiled by the large quantity of contained iron pyrites.

The order of superposition of the ganister group is given in " The Geology of the Yorkshire Coal Field: Memoirs of the Geological Survey." London, 1878, as follows :—

[The average thickness in feet of the various groups on the south are given in the left-hand margin and those of the north in the right-hand margin.]

S. Feet.		N. Feet.
540	The Elland Flagstone. Measures with irregular Sandstones and thin Coals.	360

	S. Feet.		N. Feet.
GANISTER GROUP.	150	*The Ganister or Hard Bed Coal.* Measures. *Clay or Middle Bed Coal.* Measures with middle rock. *Coking or Soft Bed Coal.*	30
	120	Crawshaw Sandstone, and Soft Bed Flags, or equivalent measures. Thin Coal and Underclay.	50
		Rough Rock.	

My friend, Mr. James W. Davis, F.L.S., of Chevinedge, Halifax, thus tabulates the series of lower coal measure beds in the Halifax district. (See "A Monograph of the Morphology and Histology of Stigmaria ficoides." By Mr. W. C. Williamson, LL.D., F.R.S., Palæontographical Society. Vol. XL, p. iv. Lond. 1886) :—

	Ft.	In.	Ft.	In.
Elland Flagrock—Flags	45	0		
,, Shales	35	0		
,, Flags	120	0		
			200	0
Shale			80	0
Eighty Yards Band Coal, or Upper Band Coal ...			0	6
Eighty yards Band Rock			15	0
Black Shales			80	0
Hard Bed Band Coal (Forty-eight yards Coal) ...			1	2
Shales with Ironstone			35	0
Thirty-six yards Band Coal			1	0
Fire Clay or Gaillard			1	6
Shale with thin Sandstones			95	0
Shale containing concretions of Carbonate of Lime with covering of Iron Pyrites. Full of Goniatites, Nantili, Orthocerata, Nuculæ, Aviculopectens.			5	0
Laminated Shale with Aviculopecten			0	4
HARD BED OR GANISTER COAL, containing concretions of Carbonate of Lime and Iron (coated and sometimes quite charged with iron-pyrites), containing vegetable remains most admirably preserved			2	2

	Ft.	In.
Ganister Rock	1	0
Seat Earth	5	0
Shale	25	0
Middle Band Coal or Clay Coal	0	6
Middle Band Rock	12	0
Shales	50	0
Soft Bed Coal	1	6
Seat Earth	2	0
Sandstone	20	0
Shale	80	0
Thin Coal	0	6
Seat Earth	5	0
Rough Rock	0	0

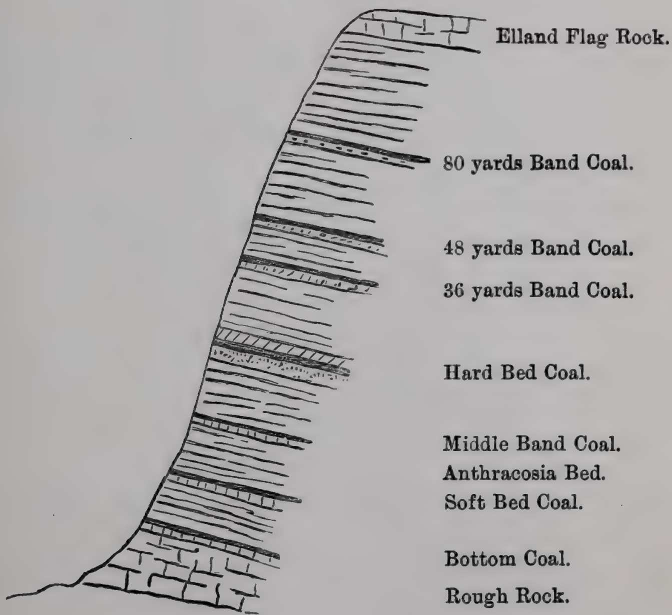

Fig. 1. Section in Lower Coal Measures, Beacon Hill, Halifax.

a. Marine Beds with "Baum Pots," containing Goniatites, Nautilus, Orthoceras, Aviculapecten, and occasionally fossil wood.

b. Hard Bed Coal, with "Coal of Balls," containing remains of plants.

c. Ganister Rock and Seat Earth.

Fig. 2. Enlarged section of the Hard Bed Coal.

Mr. James Spencer, of Halifax, who has devoted many years of his life to the enthusiastic study of the lower coal measures and their fossils and added several new forms to our local fossil flora, has kindly placed at my disposal for publication a diagram and description of a typical section of the measures found in Beacon Hill, near Halifax.

"The section of Beacon Hill on the East of Halifax, will give a good idea of the succession of the different beds composing this group.

Crowning the hill there is the valuable sandstone rock known as the Elland flagstone which is extensively quarried all around the outcrop of the coalfield from Leeds, by Bradford to Halifax, and thence to Elland, Huddersfield and Penistone. Underlying the flag-rock in descending order, there are 120 feet of shale and rag, then the 80 yards band coal, which is only about 6 inches in thickness, then 100 feet of shales and rag, followed by the 48 yards band coal of about 10 inches in thickness, then 36 feet of shales, followed by the 36 yards band coal, having from 3 to 4 feet of seat earth under it, which forms one of the most valuable fire-clays in the neighbourhood; then follow about 100 feet of shales gradually merging towards the base into fossiliferous marine strata, then come about 8 or 10 feet of shales highly charged with calcareous nodular concretions, locally known as baum pots, generally coated with pyrites, and containing

a rich and varied assortment of marine fossil shells, such as Goniatites, Nautili, Orthocerata, Aviculopecten and others, along with a few fish remains. Immediately underlying these marine strata is the *Hard Bed Coal*, containing in many places (for they are not uniformly distributed), those remarkable calcareous nodules locally known as coal-balls. The coal-balls are found in the coal itself, and in some places the whole bed is occupied by them with only a little admixture of coal, but generally they seem to be scattered throughout the coal seam at irregular intervals. Some coal pits yield them more abundantly than others.

The material composing the coal-balls consists of a mixture of carbonate of lime and carbonate of iron, with iron pyrites, calc spar, and fossilised vegetable remains. They are nearly always thickly coated with pyrites, and are often very difficult to break open, an ordinary hammer being of little use for this purpose, and too frequently the whole ball is one mass of pyrites. In composition and external appearance they somewhat resemble the nodular concretions which occur in the marine strata above the coal, but there is a total difference in their fossil contents. The "Coal-balls" contain fossil plants exclusively, while the "baumpots" contain marine shells, and sometimes fish-remains, and occasionally fragments of fossil-wood (Dadoxylon), which have evidently drifted into the sea or estuary in which the bed was originally laid down from some neighbouring land.

The hard bed coal rests upon the very peculiar rock called ganister, which varies in thickness from 1 foot 4 inches in the neighbourhood of Halifax, to 3 feet in the neighbourhood of Penistone. Underlying the ganister there is a bed of soft earth, and both seat earth and ganister are full of Stigmarian roots and rootlets, while some of the best specimens of the ordinary Stigmariæ are met with in the ganister rock About 75 feet below the hard bed coal the soft bed coal is met with, and midway between them occurs another thin seam called the middle band coal; underlying it, there is a valuable bed of fire-clay, which is extensively worked in this district. Midway between the middle-band and the soft bed coal, there are three layers of shale, which are literally full of Anthracosia, separated by black shale containing Spirorbis carbonarius.

The strata below the soft bed coal contains nothing very noteworthy in the Halifax district, but in the neighbourhood of Huddersfield occur what are called the soft bed flags, and under them certain layers of shale containing fossils such as Aviculopectens, Goniatites, and some fish remains. At the bottom of the series is a bed of coal about six inches thick, having under it the usual seat earth, these lie conformably upon the Rough Rock."

Among the various fossil fruits which have been found in the Coal Measures are small cones or fruit spikes, which were originally included in Sternberg's genus *Volkmannia*, the definition of this genus is not quite satisfactory, as indeed it may be used to designate fruit spikes, which are now distinctly referable to other well-defined genera. The two fruit-spikes exhibiting structure in our Yorkshire measures, and which were originally assigned to the genus *Volkmannia*, are *Volkmannia Dawsoni*, (*Bowmanites Dawsoni*), and *Volkmannia Binneyi*, (*Calamostachys Binneyana*.) These, along with *Calamostachys Casheana*, and Williamson's "True Fruit of the Calamities" are the only ones which I know from Yorkshire which contain structure which can be ascribed to Weiss' group of Calamariæ.

Calamostachys Binneyana was described by Professor Carruthers in Seeman's Journal of Botany, Vol. V., 1867, in a paper "On the Structure of the Fruit of Calamities," under the name of *Volkmannia Binneyi*, when, from the material then at his command, he concluded that it was a true Calamitean fruit-spike, and in comparing its organisation with that of the fruit-spike of Equisetum, he pointed out their apparent identity of organisation. In a lecture given by the learned Professor before the Royal Institution of Great Britain on 16th April, 1869, he said "A comparison of the fossil cone (*Volkmannia Binneyi*), with the fruit of Equisetum, exhibits a remarkable agreement with every point of importance. In the form of the fruit-bearing leaves, the arrangement and structure of the sporangia, the form size, and structure of the spores, even to the possession of hygrometric elaters, both fruits agree. The only difference is that in the modern plant all the leaves of the cone are fruit-bearing, while in the fossil every other whorl retains a form closely approaching that of the normal leaf of the plant. As these envelop and protect the fruit-

bearing leaves, they may be held to give to the fossil a somewhat higher systematic position than is possessed by the living genus. This superiority is further exhibited when we contrast the complex structure of the stem, and the free leaves of Calamites with the fistular and sheathless stem of Equisetum."

Binney in his "Observations on the structure of fossil plants found in the carboniferous strata," "*Calamites* and *Calamodendron*," Palæontographical Society, London; and also in his "Note on the organs of Fructification and foliage of *Calamodendron commune*," published in 1870, in the "Transactions of the Literary and Philosophical Society of Manchester, Vol. IV., third series," describes this fruit-spike and practically accepts the conclusions arrived at by Professor Carruthers. Schimper in his classical and famous work, "Traité de Palæontologie Végétale," Vol. I., Paris, 1869, also regards *Volkmannia Binneyi* as the fruit of the Calamite, at the same time referring to his genus *Calamostachys*, in which he includes the following five species :—

Calamostachys	(Calamites)	typica, Sch.
do.	do.	calamitis foliosi, Sch.
do.	do.	polystachya, Stern.
do.	do.	Binneyana, Sch.
do.	do.	major (Germ.)

He thus describes : *Calamostachys* (*Calamites*), *Binneyana*. Sch. "Spicis minutis, centimetro 1 vix longioribus, amentiformibus; bracteis e disco horizontali erectis, imbricatis, internodium paululum superantibus; sporangiophoris in quoque internodio 6 tetraspermis, ita ut 24 sporangia ibidem adsint. Tab. nostra fig. 5-10."

"Calamodendron commune E. W. Binney, Observat. on the struct. of foss. plants found in the carbon. strata; Calamites and Calamodendron, London, Palæont. Soc., 1868, tab. IV., V., avec de nombreux détails microscopiques."

"Dans des nodules de chaux carbonatée du terrain houiller du Lancashire (Angleterre.")

"Les epis dont il est question ici appartiennent sans aucun doute á une autre espèce que ceux que M. d'Ettingshausen rapporte á son *Calamites communis*, et que nous avous décrits sous le nom de *Calamostachys typica.*"

"J'ai déjá fait observer plus haut que le *Volkmannia sessilis*, Presl, le *Calamodendron commune?* et *l'Asterophyllites longifolia*, figurés á la pl. VI., du memoire de M. Binney, appartiennent a *l'Annularia longifolia*."

On the 19th June, 1873, Professor W. C. Williamson read his fifth paper "On the Organization of the Fossil Plants of the Coal Measures," in which he discusses "the relations subsisting between certain stems described by him, and the numerous fruits that have been described and figured by various observers on previous occasions." And he there contends "that the only British strobilus, of which the internal organization has hitherto been described, that has any claims to be regarded as the fruit of Calamites, is that which I figured in the fourth volume of the 'Transactions of the Manchester Literary and Philosophical Society,'" this contention and the Professor's expressed views on the structure of this strobilus have been very recently fully confirmed, and are fully expressed in his last memoir, "On the true Fructification of the Calamities." Org. of Foss. Plants of C. Meas., Pt. XIV., Phil. Trans., London, 1888. The learned Professor's views on the relation of the fruit spike of *Calamostachys Binneyana* to *Equisetum* and *Calamites* are thus summed up. "After balancing these various facts and arguments, I am led to the conclusion that *Calamostachys Binneyana* has much closer affinities with *Asterophyllites* than with *Calamites*. With the latter it has no one structural feature in common. There is no solitary point in which the two plants resemble each other. The resemblance of the fertile sporangia of *Calamostachys* to those of *Equisetum*, has been combined with the foregone conclusion that the *Calamites* were Equisetaceous plants, in leading to the belief that the two were parts of the same plant; but I cannot conceive of any conditions in which the stem of a *Calamite* could be prolonged into that of the *Calamostachys*. I have carefully investigated the relations which the fertile stems of *Equiseta* bear to axes of their terminal fruit spikes, and I find that their respective structures are typically identical. The transition from the stem to the fruit-axis produces no structural changes save such as are of the most trivial kind; the general type remains unaltered and continuous. But to place *Calamostachys*

Binneyana upon the top of a Calamite, would be as abnormal as to surmount the stem of an *Equisetum* with the strobilus of a Lycopod."

Weiss in his "Steinkohlen Calamarien, Berlin, 1876," defines *Calamostachys:* "With paniculated shorter fruit spikes, mostly with separate tracts between which are the fertile whorls, consisting usually of six column-shaped bearers, each with four sporanzia; each sporangium is attached to a disc-shaped enlargement (shield receptaculum) of the bearer; axis of the spike solid."

He classifies the fruit spikes of his group *Calamariæ* in three sections as follows:—

1. The fruit spikes consist of fertile whorls without sterile ones—*Equisetum.*

2. The fruit spikes with whorls of sterile strongly crossed foliar-discs (Deckblattkreise), the covers always on the upper end of the internodes and the fertile whorls arranged alternately; for example, the small columns or bearers are:

(*a*) Exactly in the middle betwen two sterile whorls, or in the greater distance from each of the two next whorls in *Calamostachys, Stachannularia, Macrostachya.*

(*b*) At the base of the internodes or in the angle of the discs upper leaf covers (Deckblattwinkle) in *Palæostachya*

(*c*) Discs at the upper end of the internodes under the leaf cover whorls (Deckblattwirtel) in *Cingularia Huttonia.*

3. Finally (questionable), the sporangia are sessile in the angle of the upper leaf cover, in *Volkmannia.*

R. Zeiller (végétaux Fossiles du Terrain Houiller de la France, 1880), refers *Calamostachys* to the *Annulariæ,* under the name of *Bruckmannia,* as is evident from his description, "dans ceux de ces épis (Bruckmannia), dont on a pu étudier la structure, on a reconnu des sporangiophores *disposés par verticilles alternant avec des verticilles de bractées stériles.*"

Professor Renault includes Calamostachys among the Equisetaceæ (Cours de Botanique Fossile (Deuxième Année, Paris, 1882), under the genus Bruckmannia as fructification of Annularia, "incertæ sedis," and consequently among his *Heterosporous* Equisetaceæ, in a later publication of his (Sur les fructifications des *Calamodendrons*),

he seems to take a quite different view of these fructifications thus,—"Les *Calamodendrons*, les *Arthropitus*, certains *Astérophyllites*, les *Annulariæ*, &c., présentent égalment leurs fructifications disposées d'une manière assez peu differente, *c'est à dire sous forme d'epis composés alternativement de verticilles fertiles;*" he then proceeds to discuss the fruit of *Calamodendron*, and after describing the fruit spike, sporangia and spores concludes that "the complication of organization of the sacs contained in the fruit spikes of *Calamodendrons*, and that of the reproductive bodies which they contain, bring us to the conclusion that we have here to do with pollen sacs and pollen grains, and that the *Calamodendrons* are phanerogams by their *roots*, their *stems*, and their *fructifications.*"

H. Graf zu Solms-Laubach (Einleitung in dié Paläophytologie, Leipsic, 1887), p. 339, refers to these views of Professor Renault :—

"Quite recently Renault, who formerly included all these before-mentioned fruit spikes among his Asterophyllites and Annulariæ, has formed the opinion that one part of them belongs as male elements (männliche Blüthen) to the genera *Arthropitys* and *Calamodendron*, *Calamostachys Binneyana* and C. *Grand 'Euryi* are especially mentioned as such, and their spores are straightway called pollen grains. He relies partly upon the structure of the ligneous bodies of the pith; partly upon the detailed examination of the spores, in which he recognises an inner cell arrangement of the kind seen in the pollen of Cordaites. He refers, by comparison, at the same time to the tetragonal arrangement of the spores to the tetradic Angiosperm pollen; then to the fact that similar tetragons have been found in the pollen cells of certain *Trigonocarpons* as well as of *Gnetopsis trigona*. It is difficult to criticise so dogmatic a description, especially as the fundamental basis (grandlagen) is very short and preliminary. However, I should like to say a few words. There is no analogy of a male blossom (männliche Blüthe) consisting of fertile and sterile leaf-whorls. It is not sufficient proof that we find solitary tetra-spores in the pollen vessel of wind fertilised Gymnosperms; every cell which is smaller than the micropyle opening will, if it gets attached to it, enter it. Tetradically connected spores are not indeed known, but are by no means impossible. The inner

cell body equally is no proof, taking it as I do, in spite of Strasburger's recent explanation, as a rudimentary prothallium. As we know, the microspores have such a prothallium as well, its more or less strong development is not to be considered, and after all, what is Renault going to do with Williamson's fruit-spike, containing macrospores and microspores. It will have to remain, of course, amongst the Annulariœ in spite of its resemblance to *Calomostachys Binneyana*. The only criticism that remains is the secondary wood of the spike, and thus we arrive again at the so often mentioned petitio principi of Brogniart's school, which makes so difficult to understand the writings referred to."

Though *Calamostachys* cannot be regarded as the fruit of *Calamites*, nor as a very near ally of our Equisetum, yet in the present state of our knowledge of fossil botany we may at least provisionally include, as Weiss has done, the fruit-spikes we have enumerated in one group, the *Calamariœ*. The only living genus of the group is the *Equisetum*, and the following table may serve to exhibit the chief points of resemblance and difference between that genus and *Calamostachys*:—

FRUIT-SPIKES.

(The letters given in the first column have each the same import in all the figures).

	EQUISETUM. (Plate 28.)	CALAMOSTACHYS. (Plates 22.—27.)
Axis - -	hollow or fistular -	solid.
Sterile Bracts -	none - -	twelve or more, double the number of the fertile bracts and arranged in alternate verticils with them.
Sporangiophores (fertile bracts) -	stalked peltate discs, arranged in verticils	stalked peltate discs, arranged in verticils, and in number 6 or more, always half as many as the sterile bracts.

	Equisetum.	Calamostachys.
Sporangia - -	arranged around the inner surface of the peltate discs so that they lie nearly at right angles to the central axis of the fruit-spike	arranged around the inner surface of the peltate discs so that they lie nearly at right angles to the central axis of the fruit-spike.
Spores - - - (Mic=microspores, mac=macrospores	numerous, small, nearly uniform in size (microspores) and provided with elaters	numerous small spores (microspores) having no elaters, and in C. Casheana, Williamson, there are also present large spores, macrospores.

There have appeared in "Nature" two communications respecting the spores of *Equisetum*, which, if they may be relied upon, will certainly tend to bring *Equisetum* and *Calamostachys* into a nearer relationship than they are now regarded as occupying by most palæbotanists. One of these states that a living species of *Equisetum* produces *macrospores*, the other one says that "The remarkable *Equisetum littorale, differing from all other species in the absence of elaters*, is recorded as British (and figured) by Mr. Beeby, on the faith of specimens from Surrey. Journal of Botany, March and April, 1887. Nature, 19th May, 1887, p. 70. I have seen neither of these species, and cannot help thinking that there is some error in observation, at any rate, until these supposed discoveries are confirmed, one must not use them in any way to modify ones views of the relationship of *Calamostachys* to *Equisetum*.

Sir J. W. Dawson evidently regards *Calamostachys* as the fruit of some species of *Calamites*, or at least of some allied Equisetaceous plant. In his work on "The Geological History of Plants," lately published (in the International Scientific Series, Vol. LXIII., Lond., 1888, p. 123-5), he thus speaks on this question: "All Calamites were not alike in structure. In a recent paper, Dr. Williamson describes three distinct structural types. ("Memoirs of the Philo-

sophical Society," Manchester, 1886-87.) What he regards as typical *Calamites* has, in its woody zone, wedges of barred vessels, with thick bands of cellular tissue separating them. A second type, which he refers to *Calamopitus*, has woody bundles composed of reticulated or multiporous fibres, with their porous sides parallel to the medullary rays, which are better developed than in the previous form. The intervening cellular masses are composed of elongated cells. This is a decided advance in structure, and is of the type of those forms having the most woody and largest stems, which Brogniart named *Calamodendron*. A third form, to which Dr. Williamson seems to prefer to assign this last name, has the tissue of the woody wedges barred, as in the first, but the medullary rays are better developed than in the second. In this third form the intermediate tissue, or primary medullary rays, is truly fibrous, and with the secondary medullary rays traversing it. My own observations lead me to infer that there is a fourth type of Calamitean stem, less endowed with woody matter, and having a larger fistulous or cellular cavity than any of those described by Dr. Williamson.

There is every reason to believe that all these various and complicated stems belonged to higher and nobler types of mare's-tails than those of the modern world, and that their fructification was equisetaceous, and of the form known as *Calamostachys*.

CALAMOSTACHYS BINNEYANA. Schimp.

This fruit spike consists of verticils of bracts arranged around a central axis ; these are fertile bracts and sterile ones which succeed each other in *alternate* order.

The *sterile bracts* form a sort of circular, horizontally placed foliar disc, which, on nearly reaching the surface of the fruit spike, breaks up into verticils of leaves which bend abruptly upwards nearly at right angles, and largely overlap the next sterile whorls, giving an imbricated arrangement on the exterior of the spike, these leaves, usually twelve, are double the number of the fertile bracts or sporangiophores.

The *sporangiophores* are column-shaped organs (usually six), in number half as many as the sterile bracts, they are also arranged in verticils.

Each sporangiophore stands out at right angles to the axis of the fruit spike, and is enlarged at its outer extremity into a considerably thickened *peltate disc.*

The *sporangia* or spore sacs are attached to the inner surface of each peltate disc, usually in fours, arranged around its pedicel.

The spores which show no trace of the presence of elaters fill the sporangia and are of small size, ranging in diameter from ·04 to ·05 m.m. in diameter.

The *axis* of the fruit spike is provided with a solid medulla, composed of parenchyma, the cells of which are somewhat elongated vertically, and which is enclosed in a thin cylinder of barred spiral vessels.

Professor Williamson in his memoir on the organisation of the Fossil plants of the coal-measure, read 17 June, 1880, was enabled from a specimen supplied to him from my cabinet to clear up an uncertainty as to the position of the organic union of the sporangia to the sporangiaphores.

The disc in this specimen consists of a mass of parenchyma, amongst the cells of which an extension of the bundle of spiral cells that passes along the peduncle of the sporangiophore, is prolonged towards the margin of the disc ; as the bundle approaches this margin its cells multiply as is the case with similar structures in the sporangiophores of recent Equisetum, as well as in other very different structures, *e.g.* the terminations of the hair-like emergences of the Drosera. The peripheral surface of the disc appears to have been composed of a layer of oblong cells, which are planted perpendicularly to it. Each sporangium is not connected with the peltate end of the sporangiophore by the entire base of the former, as is the case in the living equiseta, but a very narrow neck of cellular tissue attached to a point a little within the extreme overhanging margin of the sporangiophore; the remainder of the sporangium being entirely free.

I have specimens of *Calamostachys Binneyana* in my cabinet from the Halifax Hard Bed, Lower Coal Measures, of Sunny Bank and Bank Top Pits, Southowram, of Sugden Pit, near Halifax;

from Elland, from Huddersfield, and from the Upper Foot Coal of Stronesdale, Saddleworth, Yorkshire, and also from near Oldham, Lancashire.

CALAMOSTACHYS CASHEANA. Williamson.

The only other species of *Calamostachys* which to my knowledge occurs in Yorkshire is *Calamostachys Casheana*, Williamson. This was described by Professor Williamson in his eleventh memoir on the organisation of the fossil plants of the Coal Measures from a specimen discovered in the Halifax beds by the late Captain Aitken. The importance of this specimen, which in other respects agrees in the main in all its details with C. Binneyana, lies in its spores. In the slightly oblique and longitudinal section of this fruit-spike all the sporangia of the uppermost of the three fertile verticils, as well as those to the right of the middle one are filled with microspores. The three to the left of the middle verticil, and all the four of the lowermost ones contain macrospores. The microspores are about ·0031 in. and the macrospores occur as large as ·01, most of them equally ·0093 in. The latter exhibit an outer sporangial wall, as well as an inner one, whilst a dark coloured mass exists in the centre of most of the examples.

Since the publication of the paper here alluded to I have secured specimens from the Upper Foot Bed, Strinesdale, Saddleworth, in Yorkshire but close on the Lancashire Border. Figures from photographs of these are given in Plate

In our report on recent Researches amongst the Carboniferous Plants of Halifax" at 56th Meeting of the British Association, held at Birmingham in September, 1886, Dr. Williamson refers to those specimens, and to some still better preserved examples which I handed over to him for study.

"We have also obtained a fresh example of the remarkable heterosporous form of *Calamostachys*, described in Part XII. of the "Organisation of the Fossil Plants of the Coal Measures," and which latter example previously constituted the only known specimen of a Calamitean plant with bisexual fructification. This second example seems to establish clearly the distinctness of this fructification from that of the allied Calamostachys Binneyana; and I now propose that it should be known as Calamostachy Casheana."

What is the plant to which these *Calamostachys* fruit spikes should be referred, is a question which, I fear, we are not yet in a position to answer very definitely. That it belong to Weiss' group of *Calamariæ*, I have no doubt, further than that I am not at present prepared to go, except to express my opinion that it is not a true *Calamites*, and I think a comparison of the transverse section of the fruit-spike axis of Calamostachys with the stem of *Calamites* will substantiate this view. On the latter (plate XXIX.) we have a hollow stem with a pith of ordinary looking parenchyma, whose elements are rounded or polygonal in shape, and are larger and have thinner walls towards the centre than at the periphery, surrounding this is a ring of wedge-shaped masses of vascular tissue, each of which carries at its apex a well-marked internodal canal, these are enclosed by a very thin Cambium zone, outside of which is a cortex composed of three portions, the inner, middle, and outer cortical layers. This arrangement is in marked contrast to that of the axis of the *Calamostachys* fruit spikes, instead of corresponding with it in its elements as we should expect if they were both referable to the same plate. Besides all this we have Williamson's latest discovery of further examples of what he considers to be the true fruit of the *Calamites* (published in his 14th Memoir on the Organization of the Fossil Plants of the Coal Measures). in which he maintains that they are truly Calamitean, since "The most absolute of these proofs is seen in the fact that each of three of these newly discovered strobili had its basal peduncle attached to it; and that these peduncles are ordinary Calamitean twigs of the type, to which our French friends have long assigned the generic name of *Arthropitus*, and which they have, until recently, regarded as a Gymnospermous genus.

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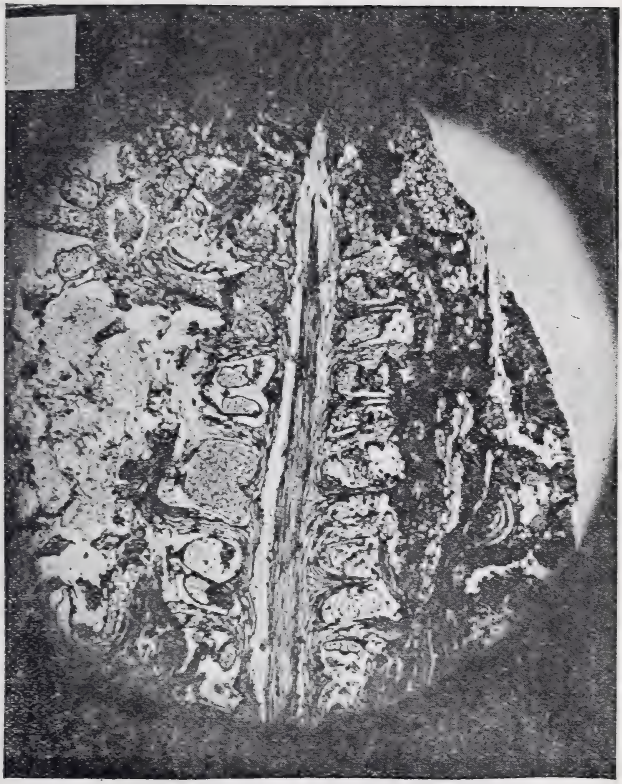
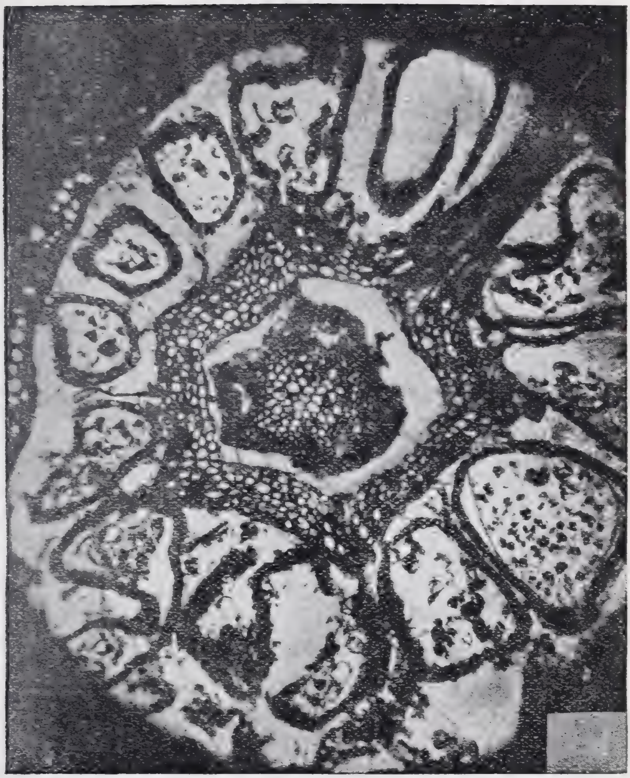


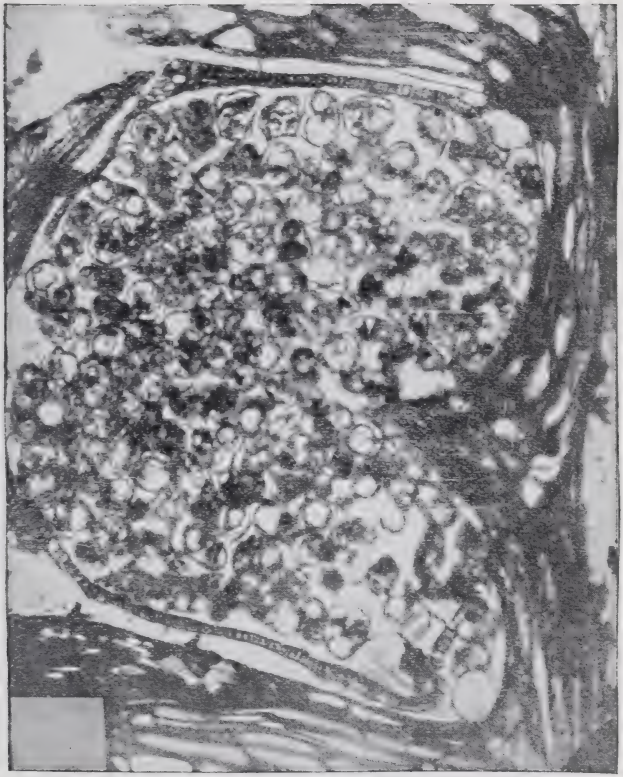
Calamostachys Binneyana, Schimp.
Vertical Section of Fruit-Spike (× 10).
Hard Bed Coal, Halifax. *Ex. coll.* W. Cash.

CALAMOSTACHYS BINNEYANA. Schimp.
Transverse Section through the Fruit-Spike ($\times$ 50).
Halifax Hard Bed Coal. *Ex. coll.* W. Cash.

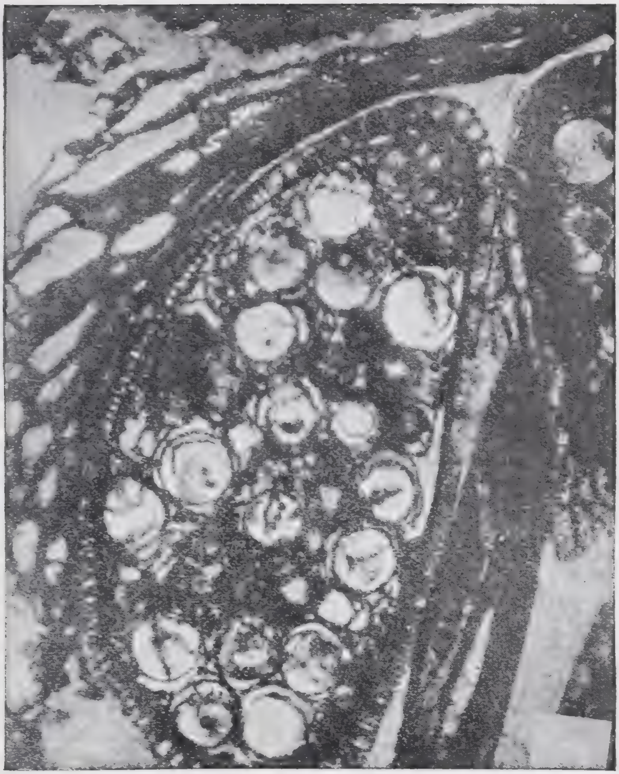
CALAMOSTACHYS CASHEANA. Williamson.
Vertical Section of Fruit-Spike (×35).
Strinesdale, Yorkshire. *Ex. coll.* W. Cash.



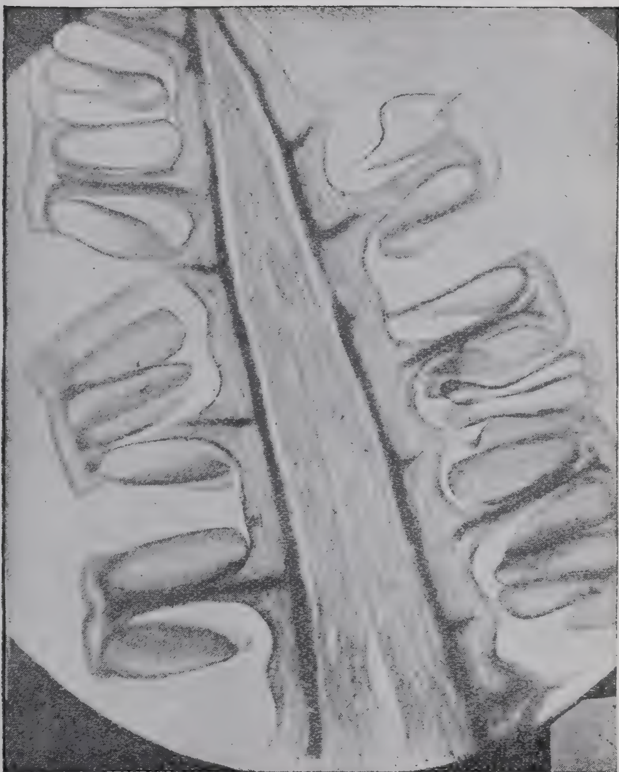
Calamostachys Casheana. Williamson.
Transverse Section of Fruit-Spike (× 64).
Strinesdale, Yorkshire. *Ex. coll.* W. Cash.



Calamostachys Binneyana. Schimp.
Section of Sporangium containing Microspores (× 108).
Hard Bed Coal, Halifax. *Ex. coll.* W. Cash.



CALAMOSTACYS CASHEANA. Williamson.
Section of Sporangium containing Macrospores (× 85).
Strinesdale, Yorkshire. *Ex. coll.* W. Cash.



EQUISETUM MAXIMUM.
Vertical Section ($\times 11$).
Ex. coll. Thos. Hick.

Transverse Section of Stem of CALAMITES with Bark (× 30).
Hard Bed Coal, Halifax. *Ex. coll.* W. Cash.

REPORT OF THE JUBILEE MEETING OF THE YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

1837—1887.

The Annual Meeting of the Yorkshire Geological and Polytechnic Society was held at the Town Hall, Ripon, on Saturday, Oct. 22nd, 1887. The President, the Marquis of Ripon, K.G., LL.D., &c., occupied the chair, and among others present were the following:—Prof. J. W. Judd, F.R.S., President of the Geological Society, London, Prof. A. H. Green, F.R.S., Prof. L. C. Miall, Prof. N. Bodington, M.A., Rev. J. S. Tute, Rev. W. C. Lukis; Messrs. J. Arthur Binns, Thos. Ormerod, James Booth, W. Townend, J. B. Dewhirst, S. A. Adamson, R. Carter, W. Horne, J. E. Bedford, Wm. Cash (treasurer), J. W. Davis (secretary), R. Reynolds, S. Seal, W. Rowley, S. T. Rigge, T. Tate, E. Slater, P. Sykes, W. Stott, R. E. Steel, S. Jury, Thos. Pratt, Arthur Briggs, T. Carter Mitchell, J. H. G. Davis, G. Buckley, Percy Davis, R. Peach, C. H. Bould, G. Harrison, C. Middleton, M. G. Dobson, W. Carr, and others.

The minutes of the previous meeting having been read and passed, the Secretary mentioned that letters of apology had been received from Dr. Henry Woodward, F.R.S., Mr. R. Etheridge, F.R.S., Mr. W. H. Huddleston, F.R.S., Mr. J. W. Woodall (Scarborough), Messrs. W. Gregson, T. W Embleton, Jno. Leach, G. W. Lamplugh, G. R. Vine, and Thos. Shaw, M.P,

Mr. James W. Davis then read the annual report as follows :—

It is with pleasure that the condition of the Society can be spoken of as continuously progressive. During the past year the number of members has been increased from 215 to 218, exclusive of those to be proposed for membership to day.

Three meetings, including the present one, have been held during the year. The first meeting was held at Halifax on July 13th, at which Mr. Alderman James Booth presided, and afterwards entertained the members present at dinner at his residence. Papers were read by the Treasurer, W. Cash, Esq., "On the genus Calamostachys"; by Rev. E. Maule Cole, M.A., "On the dry valleys

of the Chalk"; by James W. Davis, "On the occurrence of Chlamydoselachus as a Tertiary fossil," and three papers by Mr. George W. Lamplugh, "On a mammaliferous gravel at Elloughton in the valley of the Humber," "On some Glacial Sections near Bridlington," and "On the Boulders of Flambro' Head."

The second meeting assumed the form of an Excursion to the East Coast. The members met at Bridlington and under the guidance of Mr. Lamplugh visited the Cliff Sections recently exposed by the ravages of the sea near the Beaconsfield Sea-wall; rendered interesting by the exposure of the Burlington Shell Bed in the glacial clays, from which Mr. Lamplugh, assisted by Mr. Hedley, has largely increased the number of species known to exist in the beds. The party, numbering about 40, walked thence to the excavation, made under the direction of the Council of this Society, and exposing the buried cliff and ancient sea-beach. A detailed description of the results of the excavation will be given to day by Mr. Lamplugh, under whose charge the work has been mainly prosecuted. It is, however, necessary to express the thanks of the Society to Mr. Lloyd Graeme of Sewerby Hall, for his permission, readily granted to make the investigation, and for the continuous and kindly interest he has manifested in the progress of the work. It is suggested that an offer made by the Council of the York Philosophical Society to provide a case in the Museum of the Society for the exhibition of the bones should be accepted. Already the bones have been removed to York for the purpose of being gelatinized to preserve them from decay.

The members during the following days visited the red and white Chalk of Flambro' Head and the Neocomian Clays of Speeton, rendered classical by the investigations of Prof. Judd, whom we are very proud to see present to day; and a large party, guided by C. Fox-Strangways, Esq., of H.M. Geological Survey, investigated the Oolitic series exposed in the Cliffs of Filey and Gristhorpe. The animal remains obtained during the excavation of the old beach were shown to the members by Mr. Lamplugh, and Mr. Boynton very kindly exhibted the objects found during the investigation of the ancient Lake-dwellings at Ulrome.

The present meeting is the third one held this year, and in addition to its being the annual meeting it is also the Jubilee meeting of the origin of the Society. In accordance with a request of the Council, your Secretary is taking measures to prepare a history of the work of the Society, together with biographical notices of some of its early and more distinguished members. This will form the first part of a new volume of the Society's proceedings.

The Society is indebted to the following gentlemen who have represented the Society in the several towns or districts specified, as Honorary Local Secretaries:—

Barnsley	Thomas Lister, Victoria Crescent
Bradford	Thos. Tate, F.G.S., 4, Kingston Road, Leeds
Bridlington	Geo. W. Lamplugh, Bridlington Quay
Brighouse	Thomas Ormerod, Woodfield, Brighouse
Driffield	Rev. E. Maule Cole, M.A., Wetwang
Halifax	Geo. Patchett, Junr., Shaw Hill
Harrogate	R. Peach, Harrogate
Huddersfield	P. Sykes, 33, Estate Buildings
Leeds	S. A. Adamson, 52, Well Close Terrace
Leyburn and Wensleydale	Wm. Horne, Leyburn
Thirsk	W. Gregson, Baldersby, nr. Thirsk
York	H. M. Platnauer, The Museum

The proceedings and memoirs of the learned Societies, whose names are appended, are forwarded to this Society; in exchange, our proceedings were sent to them. The thanks of the Society are due and hereby tendered to those Societies for their respective contributions.

Essex Naturalists Field Club
Norwich Geological Society
Memorias de la Sociedad Cientifica "Antonio Alzate" Mexico
Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society
Royal Society of Tasmania, Van Dieman's Land
Royal Dublin Society
Royal Historical and Archæological Association of Ireland
Geologists' Association, London
Manchester Geological Society
Literary and Philosophical Society, Liverpool
Royal Institution of Cornwall
Royal Geological Society of Ireland
Midland Naturalist, Birmingham
Academy of Natural Sciences, Philadelphia, U.S.A.
Naturhistorischen Hofmuseum, Wien, Austria
Societe Imperiale des Naturalistes, Moscow
United States Geological Survey of the Territories, Washington
Boston Society of Natural History, U. S. America

Hull Literary and Philosophical Society
Connecticut Academy of Arts and Sciences
Academy of Science, St. Louis, U. S. America
Historical Society of Lancashire and Cheshire
Geological Society of London
Royal University of Norway, Christiana
Sociètè-Geologique du Nord, Lille
Royal Society of Edinburgh
Royal Geological Society of Cornwall
Royal Physical Society of Edinburgh
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn
Museum of Comparative Zoology, Cambridge. U.S.A.
Watford Natural History Society and Hertfordshire Field Club
Birmingham Natural History and Microscopical Society
Bristol Naturalists' Society
Leeds Geological Association
Patent Office Library, London
Powis Land Naturalists' Club, Aberystwith
American Philosophical Society, Philadelphia, U.S.A.
Comité Geologique de Russie, St. Petersberg.

It is desirable to draw attention to the circumstance that the subscriptions are due on the 1st January of each year, and to the great inconvenience occasioned by the non-payment of the subscriptions early in the year. The work of the Officers of the Society is thereby largely increased, and the efficiency and potential energy of the Society proportionately diminished.

The photograph issued to the members for the past year is of a fossil tree found at Clayton, near Bradford. The tree has since been purchased and removed to Owen's College, Manchester, where it has been set up under the direction of Prof. W. C. Williamson, F.R.S., so as to form a permanent record of this remarkable occurrence.

The Photograph issued with these proceedings is a section of the cliffs near Bridlington, showing a remarkable series of foldings and contortions in the glacial clays and sand.

The Honorary Secretary represented this Society at the meeting of the British Association at Manchester in the capacity of Delegate to the Conference of Corresponding Societies, and as a result of the labours of the committee, presented a preliminary Report on the Pre-historic remains of Great Britain.

Since the last meeting, in accordance with a resolution of the members, a sum of £350 has been invested in a mortgage on the corporate property of the town of Halifax. The Treasurers statement of accounts is appended.

Mr. W. Cash presented the following balance-sheet :—

Statement of Receipts and Expenditure of Yorkshire Geological and Polytechnic Society, 1886-7.

Receipts.	£	s.	d.	Paid.	£	s.	d.
To Autotype Co.—Photographs, &c.	10	17	0	By Balance brought forward	69	13	11
„ Transfer to Capital Account	71	5	10	„ Subscriptions, &c.	82	7	1
„ Advertising, Printing, &c.	50	0	0	„ Balance Interest	0	17	4
„ Sundries, Postal Expenses	2	7	9	„ Corporation Dividend	1	17	1
„ Balance at Bank	20	4	10				
	£154	15	5		£154	15	5

CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Investment with Halifax Corporation	350	0	0	By Balance	230	18	10
				„ Transfer from General Accounts	71	5	10
				„ Transfer from Raygill Fissure Account ...	47	15	4
	£350	0	0		£350	0	0

RAYGILL FISSURE ACCOUNT.

	£	s.	d.		£	s.	d.
To Transfer to Capital Account	47	15	4	By Balance brought forward	46	19	8
				„ Bank Interest	0	15	8
	£47	15	4		£47	15	4

Assets.	£	s.	d.	Liabilities.
To Halifax Corporation Bond	350	0	0	Nil
„ Balance at Bank	20	4	10	
	£370	4	10	

Audited and found correct, GEO. PATCHETT, Jun., October 21st, 1887.

The Most Noble Chairman then delivered the following address :—

Ladies and Gentlemen,—I now rise for the purpose of proposing the adoption of the report and financial statement which you have just heard read, and of submitting to you a few observations connected with the circumstances under which we are gathered together to-day. You will not naturally imagine that I am about to deliver a lecture upon geology or upon any scientific subject. I hope I know much too well to undertake the risk of speaking upon any matters of that kind in the presence of the great masters of science we have here to-day, whose presence we welcome so cordially. But it may perhaps be of interest to them, as well as to us, if I very briefly remind you of the course which this society has run during the fifty years of its existence—(applause)—for, as you have been already told, we are met here to-day in the Jubilcee year of this society. We have been celebrating another Jubilee during the course of the present year, which has called forth the warmest feelings of the people in every part of the country. But we, of this Yorkshire Geological and Polytechnic Society may, very justly I think, rejoice that our society has attained to the respectable age of 50 years, during which time I venture to think it has done good work in this country in the promotion and advancement of science. (Hear, hear.) As you are aware, this society was originally started as a West Riding Society, and was at the commencement and for a considerable number of years confined in its operations to the West Riding of Yorkshire. It had a thoroughly practical origin. It took its inception from a conviction which had spread in the year 1837, among the coal proprietors of the West Riding, and those interested in the coal mining industry, that it was of great importance to their interests as owners of collieries that geological science should be studied in this part of the country, and that geological investigations should be carried on, especially in connection with the coal fields of Yorkshire. And from that foundation the society rose. I think that, built upon that foundation it was very solidly based, and we owe much of the success which has since attended it to the fact that it had from the beginning this direct and most useful connection with one of the great industries of our county.

(Hear, hear.) No doubt we should all of us who love science, however little qualified we may be to speak of it on our own authority, unquestionably contend that science ought not to be cultivated solely for the profit it may bring to those who cultivate it—whether profit to the individual or profit to great industries. We should all feel that science should be cultivated for herself, and that it is only when so cultivated that she is ready to reveal her secrets to us. But nevertheless you will none of you disagree with me when I say that it is a very important duty of scientific men, and an important branch of scientific enquiry, that science should be brought to bear upon the great industries of the country, and that her aid should be afforded largely to the promotion of these industries in every direction. That certainly, I am convinced, is the necessity of the present day. If ever there was a time in which the connection between science and industry—the importance of it—was forcing itself more and more upon the country, that is the present day; because we are coming to see that men abroad had run ahead of us, and if we desire to keep up the character of our industrial undertakings, it can only be by bringing them into the closest possible communion with scientific investigation, and the progress of science in every direction. (Applause.) Such, ladies and gentlemen, was the origin of this society, started in the year 1837; and I find, from our records, that the first meeting of which the proceedings of our society contain an account, was held in 1839, under the presidency of the late vicar of Leeds, and Dean of Chichester, Dr. Hook. And upon that occasion that eminent man whom those who, like myself, recollect to have been one of the most remarkable men of his day—that eminent man in 1839 took an opportunity of stating his conviction that there was no real opposition between science and religion, or between religion and geology. (Hear, hear.) You know very well the strange prejudices which existed upon that subject at the time of which I am speaking, and it shows the clear-sightedness of Dr. Hook that he should have been prepared at that period to have given expression to an opinion that was not so common then among gentlemen with whom he used to associate, although it is admitted by gentlemen of every creed to-day. It must be a source of greatest gratification that these

prejudices had cleared away, and that men have come to believe that all parts of truth must proceed from one origin, and that there can be no substantial and permanent opposition between one portion of truth and another, and that belief has led to the fearless investigation of scientific questions and of nature in all her aspects, to which again we owe the great triumphs science has made during the past fifty years. The report which has just been read puts before you briefly and very clearly the present position of our society. We are not a very numerous body, but we have advanced steadily in the number of our members. We do not desire even that we should become a very numerous body, because what we wish is, that we should gather within our ranks men who have a real love for science, and men who are willing not merely to give their names to a society of this description, but to take some part in the investigations in which it is engaged. I think that all those who have watched the progress of this society for a considerable number of years, will admit that it has done good work for science during that time. In the year 1876 it was extended to the whole county of York, and we claim how to carry our investigations, and work from one end of this great county to the other. The report has shown those who were not acquainted previously with the mode in which our work is carried on, that we do not confine ourselves to the reading of papers at meetings like this, but that we also engage in practical work and in field excursions for the study of different districts in the county. I say *we*—I am afraid I ought not to use that particular word, because I have been too busy to take any part in these expeditions, and I ought therefore to say *you;* but I am desirous of identifying myself with the society—(applause),—and I hope some rays of the light of science which emanate from you may fall upon me and illuminate my mind. Our papers speak for themselves ; our transactions are published, and the report which has just been read shows the sort of connection between us and most of the scientific societies in Europe. That in itself is recognition by these eminent societies that we are working with them for a common cause, and that we are not unworthy of their notice. Within the last few hours I have heard an expression from an eminent geologist in regard to our papers, which I confess led me to

think that I should be justified in tellıng you that men of the highest distinction have found in those papers a record of investigations likely to be of lasting value, and fit to take there place permanently in scientific libraries. (Hear, hear.) Of practical work I have spoken. And now I would venture to submit to you that such a society as this, which has attained for itself the recognition of men of so much distinction, and whose papers are of the character I have spoken of, must be doing a great deal for the encouragement of natural science in this great county. It would indeed be a disgrace if a county like Yorkshire were to be behindhand in scientific matters, and if, during the fifty years of the existence of the society, its members have been doing anything for the promotion of true, honest, zealous study of natural science, especially of geological science, in Yorkshire, it has been accomplishing, I think, work the value of which will be generally recognized. I observe that it is stated in the programme that Prof. Judd will speak on the relations between the great central societies and local ones. I hope we shall hear from him that he shares the feeling which I have always entertained, that while it is desirable that the scientific work of the country should be brought to a focus in the great central societies which have their local seat in London, yet there is plenty of work for other societies to do in the various counties and provinces of the country, and they are the proper feeders of the London societies with those facts of observation which form the basis of all inductive science. I have alluded to those eminent persons who are with us to day, and I am sure you will join with me and will think I am rightly representing your feelings when I tender to them our warmest thanks for their presence on this occasion. (Applause). We are not so foolish as to suppose that we have anything to teach them, but they have a great deal to teach us if time permit. Their presence here is of extreme value, because it shows that they have persuaded themselves that the Yorkshire Geological and Polytechnic Society is doing solid work for science in this part of the country, and that it is worth the while of such eminent scientific men to come two hundred miles for the purpose of showing their interest in this society, and giving us the encouragement of their presence. (Applause.) Nothing can be more conducive to the good and to the prosperity of

an association of this description than that after fifty years of work it should receive such an *imprimatur* of the course it has been following during that lengthened period; and if that work has won this meed of approval, to this extent it must convince us, without vanity or undue pride, that we have done something for the promotion of science; and it will also be a proof to us that there is a great work for us in the future in the same direction. The circle of science is widening every day. The conquests of science during the fifty years of the life of this society have been of the most marvellous description. These conquests are not yet terminated. I speak with the greatest diffidence in the presence of the men here now, but I would venture to say that I believe I am not wrong in supposing that in very many branches of science these conquests are really only at their commencement. There has always been, and must always be, for every man a great deal more that he does not know than that which he does know, and it is for him to dive and dig in the province of the unknown and bring forth its treasures, in small quantities it may be, but increasing from time to time. And the more we can increase the sphere of what we know and diminish the regions we do not know, the more perfectly shall we carry out the purposes of these scientific associations. Therefore, there is for us an enlarging and widenning field of labour. It is our work mainly to supply facts for the consideration of the great masters of science. New facts are turning up constantly, and even in a country like this, where geological investigation has been carried so far that you might almost think there was nothing now to discover, I think I shall not be wrong if I say that that would be an erroneous conclusion, and that it would be a great mistake to rest upon our oars and to suppose that new facts were only to be found out in distant and unexplored continents. I believe there is a great deal to be done by the individual observer and the individual investigator, each in his own district, and it is to that matter especially that the members of a society of this description ought to give their special attention. The combination of science and industry is one of the most important objects of the present time, and I believe almost all men are convinced of its necessity. There may be still some persons who hold a sort of pedantic

conception, that to put science to any kind of use, or connect her with any practical work, was a degradation of science. That is an entirely erroneous and an exploded notion. (Hear, hear.) Science is not degraded by being made of the utmost possible use which she can be to industry, but industry is raised by being brought into a close connection with science; and it is only by this combination that we can hope to enable science to do that great work for the benefit of humanity, which lies before her in the time in which we live. I would indeed go so far as to say, that while scientific investigation should be conducted in a thoroughly scientific spirit, from a pure love for science, and without a mercenary regard to the pecuniary results which may attend it, yet the foremost work for us, in a great industrial district like this during the next fifty years, will be to bring science and industry into the closest possible union, and thus to afford to science the utmost possible opportunity of making her great conquests available for the advantage of mankind. (Applause.)

Mr. W. Cash then rose and said: I have here two apologies—one from Mr. Eddy, of Carleton, near Skipton, regretting that he cannot be with us; and another from Dr. Bowman. Mr. Thos. Shaw, M.P., is unable to be present. It is my pleasant duty to say a word or two about a presentation which is to be made—perhaps one of the most interesting things for which we are called together to-day. (Applause.) There is no great mystery about it. One or two friends of our well-beloved secretary, said that it was desirable that the labours that he has undergone during the past twelve years in editing our journal, and the great interest he has always shown in promoting the interests of the society, deserved at our hands some little recognition. (Applause.) One of England's greatest sons said the other day that he had spent a long life in the pursuit of truth, and when he had discovered it he had endeavoured to follow it. It seems to me it would not be a bad motto for every scientific man. (Hear, hear.) If there be one thing that a scientific man plumes himself upon more than another, it is his loyalty to truth and his earnestness in the pursuit of it. In our secretary we have one who is a lover of truth, and who has spent many years in its pursuit. (Hear, hear.) We are all delighted to take this opportunity of expressing, through the

medium of our worthy president our respect for him. (Hear, hear.) There is an address which it falls to my lot to read. It is as follows:—

To James W. Davis, Esq., F.G.S., &c., of Chevinedge.

Dear Sir,—We, the undersigned members of the Yorkshire Geological and Polytechnic Society have much pleasure in presenting you with a first-class large compound binocular microscope, with all necessary accessories, as a mark of the esteem in which we hold you personally, and as some little acknowledgment of the great services which you have rendered to the society as the Honorary Secretary and Editor of the Annual Proceedings during a period of Twelve years.

To the ability and zeal which you have shewn in this labour of love, as well as your personal efforts in generally promoting the welfare of the society, and your uniform courtesy to the members, much of its present prosperous condition must be attributed, and in the hope that you may long be spared to continue your labours, and enrich the proceedings by your own valuable researches

We subscribe ourselves,

(Signed) RIPON, President.

October, 1887.

The address contained 95 signatures. On a tablet on the microscope was the following inscription:—

Presented
to
Jas. Wm. Davis, Esqre.,
F.S.A., F.L.S., F.G.S., &c.,
The Honorary Editor and Secretary
of the
Yorkshire Geological and Polytechnic
Society,
By
The Most Hon. the Marquis of Ripon.
K,G., G.C.S.I., D.C.L., F.R.S., &c,
on behalf
of the members.
22nd October, 1887.

The President then said : It now becomes my very pleasant duty to present to you on behalf of the subscribers whose names are written under this address this microscope, of which they ask your acceptance, I trust that you will receive it from us as a proof of our very high esteem for the services which, for the lengthened period of twelve years, you have rendered to this society in the position of its hon. secretary. Your services to science date back to a longer period than that, but your services to this society, the zeal and earnestness with which you have laboured for its objects, and the life which you have inspired in it, are such as to give you the very highest claim to such an acknowledgment as that we are now taking the liberty of offering you. (Applause.) I have been now for some years president—I was going to say, of an ornamental description ; but it is you, sir, who have done the work, and it is to you that the society so greatly owes the life by which it is now animated. And under these circumstances it is indeed fitting that upon this occasion of our Jubilee, in this memorable year in the history of our society, we should take the opportunity of telling you, and others besides our own members, how highly we esteem the course you have pursued, how gratefully we recognize your services, and how earnestly we hope it may please God to spare your life, that you may still afford the society that assistance which you have hitherto given it. (Applause.)

Mr. J. W. Davis in reply said : Permit me to thank you for this beautiful and most useful present ; were I to attempt to express my sense of appreciation and gratitude for so kind a token of the kindly feeling of the members of this society towards myself, I feel that I should signally fail. It is gratifying to me to know that the services which I have attempted to render to the society, have met with the approval of you, my lord, and of the members. I have always hitherto tried to discharge the duties conscientiously, and with courtesy to all ; and if it should be the desire of the society, and it sees fit to re-elect me to the honourable office I have so much pleasure in filling, I shall, I trust, continue to serve its best interests with such zeal and care as I may be able. I thank you, my lord, ladies and gentlemen, very heartily, for this expression of sympathy and kindness you have given me. (Applause.)

Mr. W. Rowley proposed a vote of thanks to the officers of the past year for their services.

Mr. T. Carter Mitchell seconded the resolution, which was adopted.

Mr. R Carter proposed that the Marquis of Ripon, K.G., F.R.S., &c, be re-elected president. He said: To-day is not the only opportunity on which we have had the personal presence of our excellent President, the Noble Marquis, and his genial and pleasant address, would alone lead us to the conclusion that he was the right man in the right place. (Applause.)

Prof. A. H. Green seconded the resolution, which was very cordially adopted.

The President: I thank you very much for the honour you have done me in re-electing me as your president. When I call it an honour I do not use the word merely; I feel it is an honour to be at the head of a society of this kind, and I shall always feel it my duty—an agreeable duty—to do anything that may be in my power for the advantage and progress of the Yorkshire Geological Society. (Applause.)

Mr. R. Reynolds proposed that the Vice-presidents be re-elected:—

Duke of Leeds.
Earl of Dartmouth.
Earl Fitzwilliam.
Viscount Galway.
Earl of Wharncliffe.
Lord Houghton.
Viscount Halifax.
Lt.-Col. L. J. Crossley, J.P.
W. Morrison, M.P.
Thos. Shaw, M.P.
Thos. W. Tew, J.P.
H. C. Sorby, F.R.S.
W. T. W. S. Stanhope, J.P., &c.

And that James Booth, F.G.S.
Dr. F. H. Bowman, F.R.S.Ed.
Prof. A. H. Green, M.A., F.R.S.
Richard Carter, C.E., F.G.S., be added to the list

Mr. S. Seal: I have great pleasure in seconding the resolution. I think it is a very suitable list, and they will be a very worthy army of lieutenants under our noble president.

The resolution was adopted.

Mr. Jas. Booth said: I have great pleasure in proposing that Mr. Wm. Cash, be re-elected as treasurer, and that Mr. J. W. Davis, be hon. secretary for the ensuing year. I am sure all of us are exceedingly indebted to these gentlemen for the efficient services they have rendered to us in the past, and we are pretty well assured that in the future we shall have from them the same amount of efficient service. As to Mr. Cash, he keeps the accounts in a straightforward and business-like way, that they are clear and easily understood, and I am sure he is entitled to our thanks. I am thankful also to you for having elected me as one of your vice-presidents. I take a great interest in the society, and the noble Marquis has expressed exactly what we all feel, that in this society there has been good and noble work done in the past, and if it continue as it has done, good work will be done in the future.

Mr. Wm. Stott seconded this resolution, which was passed very cordially.

Mr. Davis said: I am very much obliged to you, gentlemen, for re-electing me to a position in which I have had a great deal of pleasure. The work has always been a labour of love. Difficulties arise occasionally, and it does not always happen that every member sees the same object exactly in the same light; but I trust that in the future, as in the past, members will exercise the spirit of forbearance and indulgence, and we shall continue to get on happily together, and the society will progress for many years to come. (Hear, hear.)

Mr. Cash also thanked the meeting for re-electing him treasurer.

Mr. J. Arthur Binns moved that the Council consist of the following gentlemen:—

W. Alexander, M.D.	J. E. Bedford.
R. Carter, C E.	W. Cheetham.
J. Ray Eddy.	T. W. Embleton.
Prof. A. H. Green, M.A.	T. H. Gray.
Geo. H. Parke.	R. Reynolds.
W. Rowley.	C. Fox-Strangways.

This was seconded by Mr. W. Townend, and carried.

The President: And now, gentlemen, it falls to my lot to propose the next resolution, that the following gentlemen be elected honorary members of this society:—

Prof. John W. Judd, F.R.S., President of the Geological Society, London.

Dr. Henry Woodward, F.R.S., Keeper of the Geological Collections at the British Museum.

Prof. N. Bodington, M.A., &c., Principal of the Yorkshire College.

Prof. T. McKenny Hughes, F.R.S., &c., Cambridge.

Prof. W. C. Williamson, F.R.S., Owens College.

I submit these names to you as the names of gentlemen who will do honour to the society. They are men of the very highest distinction in their respective departments of science, and their acceptance of the honorary position is a proof that they respect the work we are doing, and that it is for the general advancement of science. (Hear, hear.)

Mr. Davis seconded this, and said: From the earliest days of this society, it has been one of its privileges to elect men distinguished in science as honorary fellows, and it is only in accordance with these precedents that we are electing gentlemen whose names have been read as honorary members of the society. I am quite sure they will do honour to the society, and in thanking them for their past services, we may entertain a lively hope of favours to come. (Laughter and applause.)

Prof. Judd and Prof. Bodington each spoke his acknowledgments.

Prof. Judd then gave an address on "The relation between the central societies and local ones." He said: It has often occurred to me that the name of our society is a very striking and at the same time a suggestive one. There are many polytechnic societies, and of the geological societies there are not a few. But I believe this society is the only one which is at the same time a geological and a polytechnic society. There may be hypercritical people who would suggest that this title is a misnomer. And that if "Polytechnic"

does not include geology, then other sciences ought to be specified as well. I think the explanation of this apparently anomolous designation will be found in the fact that originally this society was "The Geological and Polytechnic Society of the *West Riding of Yorkshire;*" and the district of the West Riding is one so rich in mineral deposits—deposits of ironstone, coal, limestone, and building stone, that the science of geology which deals with questions relating to such deposits, was thereby brought into special prominence, and the name geological was added to that of polytechnic. Whether I am right or wrong in this attempted explanation of the origin of the name, I cannot but feel that I am not far wrong in ascribing to this circumstance the honour, and I will add, the great pleasure of receiving an invitation to be here to-day. It is, I know, as the representative for the time being of a great central society whose work is to investigate "the mineral structure of the earth" that I am here to-day—a society which has always taken the greatest interest and has always cultivated the most friendly relations with the Yorkshire Geological and Polytechnic Society, and I am persuaded will always continue to do so. (Hear, hear.) During the present year a great number of individuals have been called upon to exercise a considerable amount of ingenuity in seeking to discover either wonderful parallels, or striking contrasts, between the years 1837 and 1887. And it arouses in one almost a sense of personal injury to find that there is another jubilee—that of your society, dating from the same period, which seems to demand further exertions of the same kind. (Laughter.) But glancing at the history of the progress of science, a suggestion does present itself at the very surface as affording subject for profitable reflection—the date of our society does correspond very closely indeed with a crisis—a turning point in history of science. Before that date the advancement of science was almost exclusively due to the efforts of individuals. Since then, though the efforts of individuals have never been wanting, yet the efforts of individuals have been to a great extent supplemented and correlated by the labours of various scientific bodies like our own. Very strikingly does this appear if we study the history of the progress of geology in Yorkshire since 1837. Before that date

the history of geology is a record of the achievements of individuals. "There were giants on the earth in those days," and the giants had a very good time of it, because, with all the world before them they could choose the objects of their study. But now, when so many fields have been occupied and well worked out by these individuals, it is necessary that the remaining portions of the subject should be taken up in a more systematic and methodical manner, and this will perhaps be best done by the efforts of societies. Geologists will always remember that it was in Yorkshire, about the year 1673 that Martin Lister conceived the first idea of making geological, or as he calls them, "soil or mineral maps." He was strongly impressed with the contrast of Holderness, with its sands, clays and peat, and the Wolds with their chalk and flint; the moorlands of the North, with their sandstones and clays, and the mountains of the west, with their sandstones, clays and coals; and he made the valuable suggestion that the distribution of these several materials might be well shown upon maps. But it was reserved to William Smith to go much furthur than this, and to show that such maps might be made to exhibit not only the distribution, but also the true relation of stratified masses. The year 1794 is, I think, regarded by historians as one not altogether uneventful. But it has occurred to me that when distance has placed objects in something like their true perspective, the year 1794 will not be so much remembered for events that at the time have attracted the greatest attention as for others far less conspicuous. When we think of that year we shall find our interests centered, not in France or Ireland, but in Yorkshire. The time must come when Robespiere and Buonaparte become like the shadows of a nightmare or troubled dream, and when the crimes and troubles of Ireland shall have been forever forgotten in a great reconciliation, and in that time we shall think more of an event which took place in 1794 in this county of Yorkshire, when a memorable post-chaise vehicle had been seen making its way from Barnsley to Leeds, and hence to York and away to Newcastle and the north, and back by this very town towards the south. In that post-chaise was William Smith, who was engaged in obtaining a verification of that important generalisation of his

which had had such an important influence on the history of science. Another year, 1815, will be perhaps almost as conspicuous in future history, not for Waterloo, but for the construction of the first geological map in England. In 1821 Smith completed his work in connection with this part of the country by preparing the geological map of Yorkshire in four sheets. I must also refer to John Farey, the pioneer of the race of able mining surveyors, who have learned to abandon the dominion of the rule of thumb and prepare themselves for their important duties by a careful scientific training; to Wm. Buckland, who, by his researches at Kirkdale Cave, laid the foundation of that important branch of science forming the border land of geology and archæology; to Adam Sedgwick who, out of the study of the red rocks and the magnesian limestone of this county was able to elucidate "the structure of great mineral masses;" to the Rev. George Young and his companions, pioneers in palæontology, which has been so well pursued in Yorkshire, and is still cultivated in this society by our associates, Mr. Davis, Mr. Vine, and others, who are doing much excellent work, nor must I forget the important work commenced by Williamson and Hutton in studying the vertical distribution of fossils in rocks, whereby they anticipated to a great extent the work of distributing the various formations into zones.

It would be a mistake to suggest for one moment that the period before 1837, although especially characterised by the labour of individuals was not marked by the existence of any societies at all. I think I may say, however, that the societies which existed before that date were mainly engaged, not in original investigation so much as in the diffusion of knowledge. Such were the Literary and Philosophical Societies of that period, of which we must always think and speak with the greatest respect. That of Leeds was founded earliest in the year 1820; those of York and Sheffield in 1822; that of Hull in 1825, and those of Halifax and Scarborough in the year 1830. Apart from the important work which these societies performed in diffusing scientific knowledge, I may claim for them that they have exercised an important influence, in the development of scientific thought not only in Yorkshire, but throughout England, and indeed, all over the world. Like a small stone that is

thrown into a pool, which causes wider and ever widening circles to extend outwards as far as we can see, so it has been with some small and seemingly insignificant events. In the year 1824, Dr. Matthew Allen, of York, visited Kirkby Londsdale, and met Wm. Smith. After that interview an invitation was sent from York for Smith to go and lecture before the Yorkshire Philosophical Society. And as Phillips well said, this was a crisis in the history both of Smith and of Phillips himself, but it was also a crisis in the history of science, not only of Yorkshire. but all over the world. Smith had delivered his lectures, and was invited the same year to lecture at Scarbro.' It was soon found that Smith was the thinker and Phillips the lecturer. Phillips during his lecturing tours made himself thoroughly acquainted with the geology of all the different districts of Yorkshire, and the result was the publication, in two volumes, of "The Geology of Yorkshire,"—the one in 1829 and the other in 1834. But vast and important as was the work done by John Phillips in Yorkshire, we must not stop here. The first idea of the British Association was undoubtedly due to Brewster; but it is no less true that the working out of the idea to a practical issue was to a great extent dependent upon the persuasive eloquence and winning manners which always characterised John Phillips. Thus we may trace all the work that has been done by that great Association to a seemingly insignificant event which took place in 1824, when Smith was invited to come from Kirby Lonsdale to Yorkshire.

I think the influence of the British Association can be traced in turn upon this society. By its itinerant character the Yorkshire Geological Society seeks to do for Yorkshire that which has been done for the whole of England by the British Association. After the very clear and eloquent address which we have heard from our President to day, I will not attempt to follow the history of this society or trace the important work it has done; but I may point to the results which have been obtained in the way of forming scientific associations all over the country since the foundation of the society in 1837. There are now more than 60 such scientific societies. Some are geological societies and associations; others are naturalist societies; others microscopical; others field clubs; and others are societies for the promotion of the interests of various classes of pro-

fessional men such as mining engineers, agriculturalists, medical men, and so forth. And here I must remark that the multiplication of such societies is not inimical, but helpful, to our central societies. The more societies we have in Yorkshire the more will the central society of the Yorkshire Geological Society prosper. The more societies are multiplied, the better for the central societies and for science itself. Besides these societies we have more than a dozen museums in Yorkshire. I cannot help pointing to the importance of the work which has been done in Yorkshire by the extension of the Geological Survey. About 1850 it was that Sir Henry de la Beche commenced making the map, and it was a natural consequence that the man first associated with this work should be Prof. Phillips. That of Yorkshire, begun by Phillips, Smith, and Ramsay, soon came to a standstill, and was not resumed until 1867, when Prof. Green turned his attention to your great coal fields; and Yorkshire is to be congratulated that in your school of learning Prof. Green should be the first Professor of Geology. The retrospect of the last 50 years of science in Yorkshire is indeed neither unsatisfactory nor wanting in encouragement. If, turning from the past we venture to glance into the future, we cannot fail to anticipate a great development in the years to come, of this most valuable principle of the association for the advancement of science. And this must go on until every town shall have its societies, where students of kindred spirits shall meet for mutual help and encouragement; and every science shall be fed from these multiplied centres of influence; till country districts shall be overrun by field-clubs and the lecture rooms and museums of the towns shall be besieged by the dwellers in the villages; till those who labour in your own and other universities shall meet and join hands in effort with the teachers in grammar schools—aye, and in Board Schools, too, in every part of this great country—till the solace of science, the true consolations of philosophy, shall be brought within the reach of every toil-worn man and woman in this great hive of industry; and till the number be indefinitely augmented—

> "Of those that eye to eye shall look
> On knowledge, under whose command
> Is earth and earth's, and in their hand
> Is Nature like an open book."

In the evening many of the members dined together at the Unicorn Hotel, the Marquis of Ripon presiding. Afterwards several toasts were proposed.

The President gave that of "The Yorkshire Geological and Polytechnic Society," and in so doing said: it must fall to the lot of one of us to propose this toast. I think I speak the sentiments of all present when I say we have one and all derived many advantages and much pleasure from being members of this society, and I think I may be permitted to offer you very sincere congratulations upon our meeting to-day. We hear a good deal about epoch-making occasions. I cannot help hoping that this occasion, when we have been honoured by the President of the London Geological Society, may be an epoch-making occasion for us; and while we may look back with reasonable and just satisfaction to the work the society has accomplished in the last fifty years, we may look forward with a well founded hope that the conduct of the society during the next half century will be as advantageous to the interests of science in Yorkshire as has been the previous work of the society.

Prof. Green who was called upon to respond, said: It has been a matter of great regret to me that I have been able so little to be present at the meetings of this society; whenever I could be present I have endeavoured to be there. But circumstances have prevented me from giving much time for several years, and I have been obliged to content myself with hearing how well the society is prospering, and what useful work was being done.

Prof. Miall gave the toast of "The London Geological Society." He said: The Yorkshire Geological Society, whose anniversary we have been celebrating to-day, may be regarded as a bride that has been receiving the congratulations of her friends. If the President of the London Geological Society is able to see a certain degree of merit in the performance of the Yorkshire Geological Society, so much more are we conscious of the greater merit in the London Society. I ask you, in drinking this toast, to couple with it the name of Professor Judd.

Professor Judd: I have been trying to remember if I did not belong to this county. I have wanted to say "I too am a

Yorkshireman." (Hear hear). I confess I have not been very successful in finding the ground for the proud boast. I have a great sympathy with Yorkshire, and recollect that some of my earliest work with the hammer was along the shores of this beautiful county. But this is my first visit to this charming city of Ripon, and never before have I been able to partake of the beauty of Fountains. Well, I am very glad indeed to be here to-day, and especially to be the bearer of greetings to you—for I am speaking to you now in the name of all the Fellows and Officers of the Geological Society in London (Hear hear). I hope societies of this kind will abound and prosper all over the land ; and trust that this society will do even more in the future than it has done in the past for the advancement of the science in which the Geological Society of London is particularly concerned. (Applause.)

Principal Bodington : I have the honour to propose the health of "The President," who has presided over us to-day with so much geniality. There are those who know how great Lord Ripon's interest has been in this society for a great number of years I am sure those who heard his address and perceived in that address how warm his interest was in science and in the application of science, will give a cordial assent to the toast which I have the honour to propose. Our President is one who never shirks his duty. But there is something in enjoying your duty and he makes us feel that he enjoys his public duties. Lord Ripon's services to science are not confined to this society ; he does a large amount of work for the Yorkshire College, and engages in the exhilarating business of attending councils and committees, which work Professor Judd appears to think is confined to London. (Laughter and applause.)

The President, in acknowledging the toast, said : I know very well you have not chosen me for this post, because of any scientific knowledge I possess. I have been in a small way at various times a student of science—geology among others. But other vocations have prevented me from studying any science to any great extent. But I am still a student filled with the greatest admiration for science. (Hear, hear.) I think no Yorkshireman could fail to admire that sketch which Prof. Judd gave—the very interesting sketch—of the

progress of geological science. Principal Bodington has been kind enough to say that I am not in the habit of shirking public duties. Public duties are not in the habit of shirking me—(laughter)—they pursue me very steadily, and I think it is unkind of Principal Bodington that he should give you a sort of impression that there is nothing like the delight of addressing public meetings and straining your voice to the utmost in addressing yourself "to the gentlemen at the end of the hall." (Laughter.) It is not at all an unpleasant change to be able to get away from the disputes and controversies of the day in order to carry your thoughts to the ichthyosaurus and the mammoth—(laughter)—which doubtless may have had their own notions about Home Rule—(laughter)—and at all events were attached to the principles of self-government. (Laughter.) In the presence of Prof. Judd I will not attempt to give any notion of local self-government, as it prevailed in the period of those interesting animals—(laughter)—and if I made any slip in describing the municipal institutions of the carboniferous era—(laughter)—I might be called to account by Prof. Green. (Renewed laughter.) Our meeting to-day has been very pleasant to me, and I hope you gentlemen have enjoyed it. (Hear, hear.) We in Ripon are always ready to welcome all who come, and we give our visitors all the accommodation we can, we have been delighted to see you here to-day; and for myself I feel extremely grateful for the kindness of your reception. (Applause.)

Mr. Carter (Harrogate) proposing the health of "The Secretary," said: It may be that I am the oldest member of the Yorkshire Geological Society in this company, and one of those who, if not in at the formation of the society, was certainly a member a few years after it was formed, (hear, hear); and it has been my great pleasure and advantage to have been a member from that time to the present. I have seen, therefore, a number of presidents and secretaries before those whose services we have the pleasure of enjoying now. It has been, I am sure, a great happiness to all of us to unite in the testimonial we have been presenting to Mr. Davis to-day, humble though it may be as compared with his services to the society. (Hear, hear.) It is not in relation, therefore, to its value that I refer to it, but as expressing the loving attachment of a number of warm friends

—friends who are above all that flattery can suggest, who know his geniality, kindness and hospitality; and friends who have a great admiration for him as a student. (Hear, hear.) Mr. Davis is amongst the welcome contributors to the meetings of the Geological Society in London, and is appreciated by the members of that society. I am sure we all join in admiration of his services, and congratulate him upon the Jubilee Celebration to-day. (Hear, hear.) It fell to my lot to be personally acquainted with Father Smith, of whom we have heard this afternoon. I think the scientific world feels proud of the name of Father Smith, and I for one consider it one of the greatest honours of my life to have gone with him, to receive his instructions, and prepare designs for him. (Hear, hear.) These are reminiscences which it is pleasant to refer to on occasions of this sort. (Applause.)

Mr. Davis: For a dozen years or thereabouts I have had the honour of replying to the toast of the society or my own health, but I don't think I ever replied with a greater sense of diffidence than I do at the present moment. It is an extremely pleasant thing to know that you are appreciated and have the esteem of your fellows, with tokens of that esteem such as I have had to-day. But it is not equally easy to go through it all, and feel quite comfortable. I do not think that at any meeting of the society I have felt greater trepidation than I have done to-day. Nevertheless I feel extremely proud and happy in knowing I have your confidence. (Hear, hear.) I trust that the historical resumé of geological progress which we have had to-day may stimulate us all for the future. We have had illustrious ancestors, and I trust their descendants may not disgrace them. There are some geological matters in Yorkshire which still require elucidation, and I feel sure there are geologists who have not yet published an account of their knowledge of this county. I trust the young men of our society will do more than they have done hitherto, and there are many older members who might be extremely useful if they would. But it is with the greatest difficulty that I can get some of our members who, I know are quite capable, to put their thoughts to paper. We must not forget that there have been many bright and illustrious stars in geological literature who have been Yorkshiremen, and I hope we shall not in the future allow our reputation to

decline, but continue in the path laid out by others, maintain the position we ought to do in geological as well as polytechnic literature. (Hear, hear.) There is one thing that has struck me would be a happy result of this meeting, and that is to get some of our members who have known some early members of this society to write notices of such individuals. There is the Rev. Wm. Thorp whom, I dare say, Mr. Carter will recollect; then there are such men as Mr. Hartop, Mr. Wilson, the first secretary, Mr. Embleton, Dr. Alexander, who was either one of the founders or an early member Mr. Travis Clay, of Brighouse, an honorary secretary at one time, and others. Some of these gentlemen are living; and there are a number of others who did valuable work for the society, but of whom there is very little record. (Hear, hear.) I am extremely obliged to Mr. Carter, and I can assure the society it has been a source of pleasure to me to take the initiative in many of the affairs of the society, and see them carried out. I trust there is a far more glorious future for the society than it has hitherto known, and in saying this I believe I am expressing the highest ambition of its members. (Applause.)

MINUTES OF MEETINGS.

Meeting of the Council at the Museum, Leeds, on April 27th, 1887.

W. Cheetham, Esq., in the chair; present—Messrs. Carter, Tate, Gray, Adamson, Bedford, Peach, Lister, and Davis.

The minutes of the last meeting were read and confirmed.

Proposed by Mr. Tate, seconded by Mr. Gray, and carried, that the following accounts be paid:—

	£	s.	d.
Whitley & Booth	51	7	0
Autotype Co.	10	17	0
E. Wormald	2	7	6
J. Shores	0	10	0
	£65	1	6

Proposed by Mr. Bedford, seconded by Mr. Gray, and carried,

That the Hon. Secretary request Mr. E. Wormald to place such negatives of Photographs issued by the society as he may have in his possession at the disposal of the Hon. Secretary.

Proposed by Mr. Tate, seconded by Mr. Carter, and carried,

That the Hon. Secretary be instructed to invest £350 of the society's capital with the Halifax Corporation, at 3½ per cent. interest, subject to six months' notice of withdrawal on either side, and that the Halifax Corporation be requested to accept further sums of £100 at a time should such be offered.

The sum of £350 is derived from the following accounts:—

	£	s.	d.
Capital Account	230	18	10
General ,, ...	71	5	10
Raygill ,, ...	47	15	4
	£350	0	0

Moved by Mr. Carter, seconded by Mr. Lister, and carried,

That the next meeting be held at Sheffield, and that Dr. H. C. Sorby, F.R.S., be requested to preside, failing that arrangement that

Lord Halifax be requested to preside at Doncaster, or the Hon. Secretary make such arrangements as he may be able to hold a meeting during the month of May, and that papers be accepted from Messrs. Cole, Binney, Cash, Vine, and others.

It was resolved that arrangements be made to secure the attendance of some leading geologists at the annual meeting of the members to be held in October, to celebrate the 50th anniversary of the society's existence, and that the President be requested to preside.

The Hon. Secretary represented that a sum of money might, with advantage, be voted for the purpose of investigating a pre-glacial deposit at the foot of an ancient escarpment of the chalk near Bridlington, from which portions of the skeleton of an elephant have been obtained, whereupon it was resolved, on the motion of Mr. Gray, seconded by Mr. Bedford, that the society be recommended to vote £10 for this purpose.

Meeting of the Council, at the Museum, Halifax, on Wednesday, July 13th, 1887.

Dr. Wm. Alexander in the chair.

Present: Messrs. Eddy, Slater, Lamplugh, Adamson, and Davis.

The minutes of last meeting were read and confirmed.

The Secretary reported that £350 had been invested in the Halifax Corporation. That the excavation at Bridlington is to begin on Monday next, and that Mr. Wormald declined to hand over the negatives of photographs issued by the society.

Resolved that the following account be paid:—

P. W. Spencer £5 15 11

General Meeting at the Museum of the Literary and Philosophical Society, Halifax, July 13th, 1887.

Ald. James Booth, F.G.S., occupied the chair, and gave an address.

The minutes of last meeting were read and confirmed.

The following gentlemen were elected members of the society, on the motion of Mr. Adamson, seconded by Mr. Brownridge:—

Jno. Harrison Bromley, 14, Lodge View, Tong Road, Leeds.
Rev. Elijah Jackson, Victor Road, Manningham, Bradford.
Rev. Jno. Howell, Vicar of Ingleby Greenhowe, Northallerton.

The following papers were read :—

Wm. Cash, Esq.. "On the Genus Calamostachys."

G. W. Lamplugh, Esq., "On a Mammaliferous Gravel at Elloughton, in the Valley of the Humber."

G. W. Lamplugh, Esq., "On some Glacial Sections, near Bridlington. Part IV."

G. W. Lamplugh, Esq., "On the Boulders of Flamborough Head."

Rev. E. Maule Cole, M.A., "Note on the Dry Valleys of the Chalk."

Jas. W. Davis, Esq., "Note on the occurrence of Chlamyodoselachus as a Tertiary Fossil."

It was proposed by Mr. Davis, seconded by Dr. Bowman, that an excursion be made to Bridlington early in August.

Proposed by Mr. Davis, seconded by Mr. Lamplugh, that the thanks of the society be given to the Council of the Halifax Literary and Philosophical Society for the use of rooms without charge.

Dr. Bowman proposed a vote of thanks to the chairman, seconded by Mr. Jury, and carried.

After the meeting the chairman entertained the members at dinner at his residence, Spring Hall, Halifax.

A*n Excursion Meeting* was held at Bridlington Quay, on Saturday and Monday, August 6th and 8th, 1887, in order to visit the glacial beds exposed by the washing away of the Beaconsfield Seawall on the North Shore; the upper gravels between Bridlington and Sewerby; and the excavation of a buried cliff near the latter place, which was being investigated by a committee of the society, under the direction of Messrs. Lamplugh and Boynton.

Speeton was also visited to examine the Speeton Clay, the Red Chalk, and the White Chalk Cliffs at Bempton and Flamborough; and the excursion was extended to Filey and Gristhorpe, where the Oolitic series are exposed in the cliffs, and repaid investigation.

Mr. G. W. Lamplugh acted as the guide in these excursions, and he also exhibited a number of bones obtained during the investigation of the buried cliff.

Mr. C. Fox Strangways, of H. M. Geological Survey, accompanied the members to Filey and Gristhorpe.

Mr. Thos. Boynton exhibited a large collection of objects obtained from the Lake Dwellings at Ulrome.

Meeting of the Council at the Museum, Leeds, Sept. 22nd, 1887. Wm. Cheetham, Esq., in the chair.

Present, Messrs. Tate, Bedford and Davis.

A communication from the President was read, suggesting that the Jubilee Meeting be held at Ripon, on Saturday, October 22nd, at 3 p.m. It was decided that the suggestion be adopted.

Proposed by Mr. Bedford, seconded by Mr. Tate, and carried.

That the following gentlemen be invited to be present :—

The President of the Geological Society, London, Prof. J. W. Judd.

The Keeper of the Geological Collections, British Museum, Dr. Hy. Woodward,

The Assistant-Keeper of the Geological Collections, British Museum, R. Etheridge, Esq.

Principal Bodington, Yorkshire College, Leeds.

Prof. Green, Yorkshire College, Leeds.

Prof. Miall, Yorkshire College, Leeds.

Prof. T. Mc. K. Hughes, Cambridge.

Proposed by Mr. Tate, seconded by Mr. Bedford, that the Hon. Secretary be requested to prepare a short history of the society, and that papers be read by the following gentlemen :—Messrs. Tate, Boynton, Holmes, Vine, H. Wilson, J. W. Davis, Lamplugh, and Bedford.

Jubilee Meeting held in the Town Hall, Ripon, at 3 p.m. October 22nd, 1887.

A report of a portion of the proceedings of the Jubilee Meeting will be found on page 459.

Proposed by Mr. R. E. Steele, seconded by Mr. W. Cash, and carried, that the following gentlemen be elected members :—

Geoffrey Hastings, 16, Neal Street, Bradford.

J. E. Jones, Solicitor, Halifax.

Jas. Ross, Esq., Harrogate.

Prof. Judd, F.R.S., gave an address "On the Relation between great Central Societies and Local Ones."

Principal Bodington "On the New Seats of Learning."

Profs. Green and Miall briefly addressed the meeting.

The following papers were read:—

G. W. Lamplugh, Esq., "Report on the Excavation of an Ancient Sea Beach at Sewerby."

Thos. Tate, Esq., F.G.S., "Yorkshire Petrology. Part I. The Lamprophyres."

Geo. R. Vine. Esq., "Notes on the Classification of the Cyclostomatous Polyzoa, old and new."

H. Wilson, Esq., "Biographical Notice of Thos. Wilson," a former secretary of the society.

J. E. Bedford, Esq , "Notes on some Neolithic Implements found in the Isle of Man."

Jno. Holmes, Esq., "Pre-historic Implements found near Leeds."

Thos. Boynton, Esq., "Bronze Implements found near Bridlington."

Jas. W. Davis, Esq., "Pre-historic Flint-users of Yorkshire."

Proposed by Mr. J. B. Dewhirst, seconded by Mr. A. Briggs, and carried, that the thanks of the meeting be given to Professors Judd, Green, and Miall, and to Principal Bodington for their attendance and addresses.

A vote of thanks to the Chairman terminated the proceedings.

The members, between 50 and 60 in number, dined together at the Unicorn Hotel; the Marquis of Ripon presiding.

Meeting of the Council, December 14th, 1887, at the Museum, Leeds.

Richard Carter, Esq., C.E., in the chair.

Present, Messrs. Adamson, Cheetham, Bedford, Gray, Ormerod, Reynolds, Rowley, Tate, and Davis.

Proposed by Mr. Cheetham, seconded by Mr. Ormerod, and carried, that the scheme suggested by the Hon. Secretary to publish an account of the 50 years' work of the society, together with biographical notices of its principal members, be adopted.

Proposed by the Chairman, and seconded by Mr. Ormerod, that Messrs. Reynolds and Rowley be requested to obtain the early minute books of the society if such be accessible.

Summary of Geological Literature relating to Yorkshire, Published during 1887.

Compiled by JAMES W. DAVIS.

ADAMSON, S. A. On the Discovery of a Stone Implement in Alluvial Gravels at Barnsley. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 281.

——— Notes on the Discovery of a large Fossil Tree in the Lower Coal Measures at Clayton, near Bradford. *Rep. Brit. Assoc.*, Birmingham, p. 628.

ANON. Colliery Explosions and the Weather of 1885. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., fig. 248.

BLAKE, PROF. J. F. On a new specimen of Solaster Murchisoni, from the Yorkshire Lias (base of Huntcliffe.) *Geol. Mag.*, vol. iv., p. 529.

BONNEY, PROF. T. G. Presidential Address to the Geological Section (reference to rock formation in Yorkshire.) *Rep. Brit. Assoc.*, Birmingham, p. 601.

CROSSKEY, Dr. H. W Committee to record the Erratic Blocks of England, Wales, and Ireland (refers to Yorkshire erratics.) *Rep. Bri. Assoc.*, p. 223.

DAVIS, JAMES W. On the Relative Age of the Remains of Man in Yorkshire. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 201.

——— On some Remains of Fossil Trees in the Lower Coal Measures at Clayton, near Halifax (Photograph.) *Ibid*, p. 253.

——— On the Exploration of the Raygill Fissure in Lothersdale. *Ibid*, p. 280. Also, *Rep. Br. Assoc.*, Birmingham, p. 469. *Ibid*, p. 665.

——— Summary of Geological Literature for 1885-6. *Proc. Yorksh. Geol. and Polyt. Soc.*, p. 328.

DAWSON, SIR J. WILLIAM. On Canadian examples of supposed Fossil Algæ. *Rep. Brit. Assoc*, Birmingham, p. 651. (Refers to Protichnites Divisii of Williamson from the Yoredale Rocks, near Hawes.)

DONALD, MISS JANE. Notes upon some carboniferous species of Murchisonia in our Public Museums. *Quart. Journ. Geol. Soc.*, vol. xliii., p. 617. (Frequent references to Yorkshire specimens.)

EMBLETON, T. W. Notes on Ancient Coal Mining. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix, p. 257.

GARDNER, J. S., and others. On the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom. *Rep. Brit. Assoc.*, Birmingham, p. 241. (From Jurassic of Yorkshire and Specimens in York Museum.)

GRESLEY, W. S. Notes on "Cone-in-Cone" Structure. *Geol. Mag.*, vol. iv., p. 17. (Specimens in the Yorkshire College.)

HINDE, GEO. J. On the Organic origin of the Chert in the Carboniferous Limestone series of Ireland, and its similarity to that in the corresponding strata in North Wales and Yorkshire. *Geol. Mag.*, vol. iv., p. 435.

HOLMES, J. A sketch of the Pre-historic Remains on Rombalds Moor. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 283.

HORNE, W. On Pre-historic Remains recently Discovered in Wensleydale. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 175.

HULL, PROF. ED. Dr. Hinde on the origin of Carboniferous Chert. *Geol. Mag.*, vol. iv., p. 524.

JONES, T. R., ETHERIDGE, R., and WOODWARD, Dr. H. On the Fossil Phyllopoda of the Palæozoic Rocks. *Rep. Brit. Assoc.* Birmingham, p. 229. (Examples from Helm Knot, Dent, &c.)

KINAHAN, G. H. Chert in Irish Carboniferous rocks. Correspondence *Geol. Mag.*, vol. iv., p. 521. As compared with that of Yorkshire, by Dr. Hinde, *op. cit.* p. 435.)

LEBOUR, PROF. G. A. On the Stratigraphical position of the Salt measures in South Durham. *Geol. Mag.*, vol. iv.. p. 39. (Middlesbrough.) *Also, Rep. Brit. Assoc.* Birmingham, p. 673.

LEWIS, PROF. H. CARVILL. Glaciation of N. America, Great Britain and Ireland, *Geol. Mag.*, vol. iv., p. 28. (Refers largely to Yorkshire.) *Also, Rep. Br. Assoc*, Birmingham, p. 632.

——— ——— On some extra Morainic Lakes in Central England, North America and elsewhere, during the period of Maximum Glaciation, and on the origin of extra morainic Boulder Clay. Notice in *Geol. Mag.*, vol. iv., p. 515. (Vale of York, Valley of the Aire, &c.)

LUPTON, PROF, ARNOLD, On Safety Lamps *Proc. Yorksh. Geol & Polyt. Soc.*, vol. ix., p. 268.

MARR, J. E. The work of Ice Sheets. *Geol. Mag.*, vol. iv., p. 151. (Yorkshire.)

——— ——— The Lower Palæozoic Rocks near Settle, *Geol. Mag.*, vol. iv., p. 35. *Also Rep. Br. Assoc.* Birmingham. p 663.

MCLANDESBOROUGH, J., and PRESTON, A. E. Meteorology of Bradford, for 1866. *Proc. Yorksh Geol. & Polyt. Soc.*, vol. ix. sheets 1 and 2.

MELDOLA, PROF. R., and others. Report to the Council of the Corresponding Societies. *Rep. Brit. Assoc.* Birmingham. p. 285. (Frequent references to Yorkshire Societies' work.)

MELLO, REV. J. MAGENS. On the Microscopical Structure of Rocks. *Proc. Yorksh. Geol. & Polyt. Soc.*, vol. ix., p. 151.

MILLER HUGH. On the classification of the Carboniferous Limestone Series. *Rep. Brit. Assoc.* Birmingham, p. 674. *Geol. Mag.*, vol. iv., p. 117. (Yorkshire series compared.)

MITCHELL, JOSEPH. On Explosives used in Mining. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix.. p. 147.

MORTIMER, J. R. On the Habitation Terraces of the East Riding. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 221.

REYNOLDS, R. Abnormal Barometrical disturbances in Yorkshire in 1883, and 1884. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 214.

SORBY, DR. H. C. On some remarkable properties of the characteristic constituents of Steel. *Proc. Yorksh. Geol. and Polyt. Soc* Vol. ix., p. 145.

SPENCER JNO. On Boulders found in Seams of Coal. *Quart. Journ. Geol. Soc*, vol. xliii., p. 374. (Refers to Leeds Specimens.)

STOCKS, H. B. On a Concretion called Acrespire. *Proc. Yorksh. Geol & Polyt. Soc*, vol. ix., p. 149.

——— ——— On Concretions. *Rep. Br. Assoc.* Birmingham. p. 670.

TRANS. OF THE LEEDS GEOL. ASSOC. Review. *Geol. Mag.*, vol. iv., p. 326.

TUTE, REV. J. STANLEY On the Cayton Gill Beds. *Proc Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 265.

VINE, G. R. Notes on the Polyzoa of the Wenlock Shales. *Proc. Yorksh. Geol. and Polyt. Soc.*, vol. ix., p. 179.

——— ——— Notes on the Palæontology of the Wenlock Shales of Shropshire. *Ibid.* p. 224.

WILLIAMSON, W. C. On recent researches amongst Carboniferous Plants of Halifax. *Rep. Br. Assoc.*, Birmingham, p. 654. (Amongst others a new species of Calamostachys named after its discoverer, C. Casheana.

WILSON E. British Liassic Gasteropoda. *Geol. Mag.*, vol. iv., p. 193. (89 sp. in Yorkshire.)

WOODWARD, DR. H. On some spined myriapods from the Carboniferous Series of England. *Geol. Mag.*. Vol. iv., p. 1. (Grassington, Yorkshire,)

WOODWARD, HORACE B. The Geology of England and Wales, 2nd Ed., pp. 670, with Geological Map, and 103 Illustrations, London, 1887. *See* Review in *Geol. Mag.*, vol. iv., pp. 314-320. (W. H. Huddleston.)

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*).

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***It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1887.

SHEET 1.

Computed from daily observations made at the Exchange, Bradford, by John McLaudsborough, F.R.A.S., F.R.Met.Soc., F.G.S., and Alfred Eloy Preston, Assoc. M. Inst. C.E., F.R.Met.Soc., F.G.S.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Mean of Highest of 19 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 19 Years	Range	Corrected for Capillarity and Temperature: Mean	Mean of 19 Years	Temperature of Air in Shade during Month: Highest	Date	Mean of Highest daily of 19 Years	Lowest	Date	Mean of Lowest daily of 19 Years	Range
	Ins	On	Ins	Ins	On	Ins	Ins	Ins	Ins	Deg	On	Deg	Deg	On	Deg	Deg
January	30 209	20th	30 165	28 462	5th	28 679	1 747	29 487	29 503	53 3	31st	52 8	21 1	17th	23 5	32 2
February	30 412	8th	30 078	28 226	2nd	28 765	1 186	29 827	29 497	56 6	28th	53 7	24 6	10th	26 7	32 0
March	30 232	2nd	30 137	28 601	23rd	28 807	1 631	29 620	29 512	56 6	1st	57 0	22 7	17th	25 9	33 9
April	30 280	17th	30 084	28 860	23rd	28 813	1 420	29 567	29 479	58 0	13th	64 6	29 6	15th	31 3	28 4
May	30 114	14th	30 059	28 769	20th	29 030	1 345	29 606	29 553	67 0	9th	69 6	33 9	2nd	34 6	33 1
June	30 138	30th	30 108	29 380	3rd	29 165	0 758	29 743	29 556	79 6	19th	77 3	42 2	1st	41 7	37 4
July	30 006	1st	29 976	29 160	27th	29 154	0 846	29 573	29 521	82 8	9th	80 6	42 8	6th	46 6	40 0
August	30 055	3rd	29 986	28 993	31st	29 068	1 062	29 541	29 510	81 2	7th	78 7	38 6	14th	45 4	42 6
September	30 201	24th	30 077	28 583	2nd	28 942	1 618	29 459	29 494	63 4	1st	70 6	33 6	28th	33 9	29 8
October	30 221	17th	30 124	28 920	30th	28·743	1 301	29 672	29 454	57 3	3rd	63 4	30 8	12th	32 7	26 5
November	29 947	16th	30 045	28 328	3rd	28 668	1 619	29 290	29 435	52 0	27th	56 3	27 6	16th	28 4	24 4
December	30 078	2nd	30 101	28 819	6th	28 655	1 199	29 347	29 455	50 9	14th	52 8	24 8	29th	23 2	26 1
Means, or totals	30 153		30 070	28 842		28 874	1 311	29 561	29 497	65 2		64 8	31 0		33 3	32 2

Months	Mean In Each Month: Of all Highest	Mean of 19 Years	Of all Lowest	Mean of 19 Years	Daily Range: Mean	Mean of 19 Years	Of Dry Bulb: Mean	Mean of 19 Years	Adopted Mean Temperature of Air: Mean	Mean of 19 Years	Of Evaporation: Mean	Mean of 19 Years	Dew Point: Mean	Mean of 19 Years	Vapour, Elastic Force: Mean	Mean of 19 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Ins	Ins
January	41 7	42 9	32 6	34 2	9 1	8 7	38 0	39 1	37 5	38 7	35 7	37 5	33 2	34 7	190	203
February	44 8	44 5	34 7	35 5	10 1	9 0	39 3	40 0	39 3	39 8	37 0	38 1	34 0	35 8	196	211
March	44 4	46 7	33 7	35 4	10 7	11 3	38 8	40 6	38 4	40 2	35 8	37 9	32 6	34 9	184	204
April	50 9	53 0	37 1	39 6	13 8	13 4	42 6	44 9	42 5	44 9	38 9	41 6	34 5	37 7	207	229
May	54 2	58 1	42 9	43 6	11 3	14 6	47 8	49 3	47 3	49 2	43 9	44 9	40 1	40 8	256	257
June	68 5	65 2	52 0	50 0	16 5	15 2	58 5	55 8	58 5	55 7	52 7	51 2	47 5	46 7	30	320
July	72 2	68 8	55 8	54 1	16 4	14 8	63 3	60 5	62 7	60 3	55 5	54 6	49 3	50 3	353	366
August	67 5	67 6	51 7	53 2	15 8	14 4	58 2	59 1	58 0	58 9	52 1	54 1	46 8	50 3	320	365
September	58 2	62 0	47 9	49 5	10 3	12 5	52 3	54 5	52 0	54 6	48 7	51 3	45 3	48 0	303	336
October	50 4	53 9	40 1	43 3	10 3	10 6	45 1	48 2	44 6	47 9	41 2	45 5	36 8	42 7	238	276
November	44 5	47 1	37 6	38 1	6 9	9 6	40 6	42 6	40 6	42 3	38 6	40 0	35 8	37 2	210	223
December	42 7	42 6	34 1	34 2	8 6	8 4	38 5	39 0	38 4	38 6	36 1	36 6	33 0	34 2	188	199
Means, or totals	53 3	54 4	41 7	42 8	11 6	11 8	46 9	47 8	46 6	47 6	43 0	44 4	39 1	41 1	246	266

Months	Vapour, In a Cubic Foot of Air: Mean	Mean of 19 Years	Short of Saturation	Mean of 19 Years	Mean Weight of a Cubic Foot of Air	Mean of 19 Years	Degree of Humidity, Complete Saturation = 100: Highest	Date	Mean of Highest of 19 Years	Lowest	Date	Mean of Lowest of 19 Years	Mean	Mean of 19 Years
	Grs	Grs	Grs	Grs	Grs	Grs	0–100	On	0–100	0–100	On	0–100	0–100	0–100
January	2 2	2 4	0 5	0 4	551	549	99	14th	97	63	25th	67	85	86
February	2 3	2 5	0 5	0 4	554	547	93	17th	97	42	28th	67	82	86
March	2 2	2 4	0 6	0 5	551	547	98	5th	96	55	24th	67	80	83
April	2 3	2 7	0 8	0 8	546	541	100	21st	94	49	26th	53	74	77
May	2 8	2 9	0 9	1 1	541	537	94	25th	97	44	31st	45	77	74
June	3 7	3 6	1 8	1 4	533	531	91	26th	93	43	27th	49	68	72
July	3 9	4 1	2 4	1 7	524	526	84	13th	91	35	9th	49	62	70
August	3 6	4 1	1 8	1 5	528	526	90	13th	92	41	24th	51	66	74
September	3 4	3 8	1 0	1 0	533	531	99	2nd	86	62	8th	56	78	78
October	2 6	3 2	0 8	0 6	545	537	90	9th	96	51	11th	62	73	83
November	2 4	2 6	0 5	0 5	543	543	99	21st	96	66	12th	63	84	83
December	2 2	2 3	0 6	0 5	546	548	93	13th	97	68	10th	66	81	84
Means, or totals	2 8	3 0	1 0	0 9	541	539	94		95	51		57	76	79

Months	Bright Sunshine: Greatest Daily Duration	Date	Total of Month	Per cent. of Possible Duration	Temperature of Air in Sun's Rays: Highest	Date	Mean of Highest of 19 Years	Mean	Mean of 19 Years	Wind Direction: Relative Proportion of at 9 a.m.: N	NE	E	SE	S	SW	W	NW
	hr min	On	hr min		Deg	On	Deg	Deg	Deg	No	No	No	No	No	No	No	No
January	5 30	30th	19 0	8	67 [illegible]	31st	60 6	62 7	48 1	3	1	2	3	5	6	8	3
February	6 40	27th	52 55	19	9[illegible]	28th	72 1	58 7	53 2	1	6	1	3	4	6	4	3
March	9 50	28th	99 4	27	77 [illegible]	29th	83·5	63 9	62 0	7	3	1	6	0	1	7	6
April	9 0	13th	133 58	32	83 [illegible]	4th	96 7	70 8	73 1	2	7	3	2	1	6	7	2
May	7 55	10th	78 3	16	92 [illegible]	9th	104 3	72 1	80 9	5	10	2	2	0	1	4	7
June	12 10	19th	176 50	35	104 [illegible]	18th	110 9	91 6	87 8	2	6	4	3	4	2	4	5
July	12 40	3rd	191 30	38	107 [illegible]	9th	113 7	85 9	92 1	4	1	2	0	4	8	10	2
August	11 40	15th	169 5	37	103 [illegible]	7th	119 5	89 1	89 6	0	4	2	4	1	3	7	10
September	6 35	9th	84 40	22	87 [illegible]	1st	99 3	76 1	80 6	2	8	2	1	0	10	4	3
October	7 20	25th	80 18	25	79 [illegible]	3rd	86 2	68 6	67 0	11	2	0	0	0	4	2	12
November	4 5	16th	18 50	7	67 [illegible]	6th	71 4	56 0	55 4	7	9	1	2	0	5	6	0
December	3 15	1st	16 45	7	66 [illegible]	4th	57 7	61 7	47 1	9	1	2	0	2	5	6	6
Means, or totals	8 3		1120 58	25	84·[illegible]		88 9	70 6	69 7	53	58	22	26	21	67	69	59

Months	Wind Velocity At 9 a.m.: Mean	Highest	Date	During 24 hours: Mean	Highest	Date	Total Registered in Month	Pressure: Mean of all Daily Highest	Mean of all Daily Highest of 4 Years	Highest	Direction	Date	Mean of Highest of Month of 4 Years	Mean Amount of Cloud	Rain: Number of Days it fell	Amount Collected	Greatest Daily Fall	Date	Mean of 18 Years	Mean of Seven Years ending with 1882, 65½ft. above surface of ground	Mean of 7 Yrs ending with 1882 at T'n Hall and M'd Ry. Station on surface of ground	Gr'ter fall on surface at Town Hall & Mid. Stn. than at 65½ft. above surface at Exch.: Depth in Inches	Percentage of fall at Exch'ge
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	On	Miles	lb per sq ft	lb per sq ft	lb per sq ft		On	lb per sq ft	0–10	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	6 4	14 0	21st	148	282	22nd	4610	2 15	3 69	8 50	W	22nd	13 56	8 3	14	1 72	0 33	8th	2 79	2 209	2 474	0 265	11 2
February	8 3	30 2	3rd	186	462	26th	5192	3 36	3 16	15 00	W S W	4th	11 50	7 8	11	0 73	0 17	1st	1 95	2 609	2 972	0 363	11 4
March	6 8	20 4	25th	149	299	28th	4621	2 18	2 38	11 50	W	28th	12 00	7 2	9	1 73	0 68	23rd	2 18	2 776	3 260	0 484	11 7
April	8 7	19 6	6th	188	300	1st	5569	3 03	2 78	10 00	W	1st	10 19	6 6	14	0 65	0 17	29th	2 08	2 516	2 835	0 319	11 2
May	8 0	15 2	20th	173	297	21st	5349	1 99	2 65	7 76	W N W	20th	8 94	7 7	15	1 51	0 69	20th	1 80	2 103	2 277	0 174	10 8
June	6 9	14 6	9th	151	231	13th	4525	1 25	1 79	6 75	W	10th	7 19	6 8	4	0 03	0 64	4th	2 38	2 837	3 011	0 174	10 6
July	7 6	12 9	13th	164	284	27th	4771	1 14	1 76	6 25	S W	26th	6 00	6 8	10	1 39	0 43	27th	2 97	3 401	3 641	0 240	10 7
August	6 4	16 2	30th	131	261	9th	4064	1 26	1 77	9 50	W	10th	7 62	6 9	11	1 24	0 20	29th	2 53	3 654	3 892	0 238	10 7
September	8 2	17 0	6th	162	260	3rd	4846	1·32	2·38	4 25	S W	6th	7 44	7 7	19	3 51	0 67	2nd	2 93	2 894	3 229	0 335	11 2
October	7 6	14 2	27th	165	298	27th	5104	1 72	2 88	5 00	S W	27th	10 81	7 2	13	2 13	0 81	9th	3 56	3 640	4 012	0 372	11 0
November	6·3	20 4	1st	134	331	27th	4026	1 68	2 23	9 50	S W	27th	10 88	8 0	19	2 05	0 40	6th	2 81	3 421	3 828	0 407	11 2
December	7 4	21 8	17th	160	364	17th	4467	2 45	3 61	11 00	W	17th	14 06	7 6	21	1 91	0 31	7th	2 63	3 681	4 170	0 489	11 3
Means, or totals	7 4	18 0		158	303		57644	1 95	2 69	8 71			10 01	7 3	160	18 66	0 41		29 25	35 741	39 601	3 860	11 08

METEOROLOGY OF BRADFORD FOR 1887.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year	Pressure: Highest: Reading of Barom during Year	Date	Pressure: Lowest: Reading of Barom during Year	Date	Temperature: In Shade: Highest: R'ding of Maximum Thermom during Yr	Date	In Shade: Lowest: R'ding of Minimum Thermom during Yr	Date	Last and First Frost of Seasons: Date of Last Frost	Date of First Frost
	Ins		Ins		Deg		Deg			
1869	30 290	Dec 6	28 500	Feb 1	65 2	Aug 30	19 8	Dec 28	Mar 27	Oct 20
1870	30 264	Jan 19	28 308	Jan 8	85 0	July 25	16 6	Dec 23	Mar 30	Nov 9
1871	30 152	Mar 28	28 308	Jan 16	84 0	Aug 12	6 7	Jan 1	April 11	Nov 13
1872	30 156	April 6	28 070	Jan. 24	66 4	July 23	24 8	Mar 27	Mar 27	Nov 19
1873	30 338	Feb 18	28 022	Jan 20	68 8	July 23	19 2	Feb 24	Mar 14	Nov 5
1874	30 476	Mar. 6	28·276	Dec. 11	80·9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11
1875	30·305	July 7	28 484	Nov. 10	80·0	Aug. 17	13·0	Jan. 1	Mar. 22	Nov. 26
1876	30 300	Jan. 15	28 070	Dec. 4	87·6	July 17	23·0	Jan. 9	April 15	Nov. 8
1877	30 358	Oct 6	28 300	Nov 29	80 0	June 19	20 0	Mar 1	May 4	Oct 18
1878	30 320	Mar 16	28 630	April 1	89·6	July 18	13·9	Dec. 26	April 6	Nov. 9
1879	30 352	Dec 13	28 500	Feb. 10	74 4	July 30	13 2	Dec 7	May 10	Nov 14
1880	30 332	Jan 7	28 154	Nov 16	81 3	Sep 5	20 8	Jan 20	Feb. 23	Oct 20
1881	30 382	May 10	28 250	Oct 14	64 3	July 6	12 0	Jan 26	April 21	Oct 17
1882	30 544	Jan 18	28 452	Mar 1	77 4	Aug 12	18 6	Dec 11	April 16	Nov 12
1883	30 500	April 9	28 452	Sep 2	76 2	July 3	19 8	Mar 10	Mar 29	Nov 12
1884	30 354	Oct 5	28 376	Jan 27	84 4	Aug 12	26 5	Nov 30	April 24	Nov 24
1885	30 273	Mar. 14	28 400	Jan. 11	82 2	July 27	22·1	Dec. 11	April 5	Nov. 16
1886	30 355	Nov. 24	27·652	Dec. 8	79·5	July 3	17·4	Mar. 7	April 30	Dec. 2
1887	30 412	Feb 8	28 328	Nov 3	82 8	July 9	21 1	Jan 17	April 17	Oct 12
Means	30 347		28 291		82 6		18 1			

Year	Temperature: In Sun's Rays: Highest: Reading of Solar Thermom during Yr	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Yr	Date	Humidity: Lowest: Degree of Humidity during Yr	Date	Bright Sunshine: Greatest Daily Duration	Date	Total of Year	Per cent of Possible Duration	Wind Pressure: Highest	Date
	Deg		0 100		0 100		hr min		hr min		lb per sq ft	
1869	127 7	Aug 30	99	Feb 8	42	Sep 24						
1870	127 6	July 25	98	Jan 29	40	July 14						
1871	128 7	July 17	98	July 7	43	Nov 2						
1872	124 8	Aug 19	100	Mar 22	45	Sep 23						
1873	124 5	July 23	100	Dec 11	41	Mar 26						
1874	125·6	July 20	100	Feb. 6	42	May 18						
1875	122·0	July 5	100	Jan. 23	43	July 6						
1876	125 6	July 16	99	Oct. 4	46	May 5	......	......	......	......	......	......
1877	116 4	June 19	100	Oct 29	35	May 23						
1878	118·2	July 22	99	Jan. 13	53	Aug 9						
1879	101 2	Aug 13	100	Oct 7	51	Dec 12						
1880	112 0	Aug 13	99	Dec 15	50	May 30						
1881	116 5	June 1	98	Oct 14	38	May 31						
1882	108 0	Aug 9	99	Nov 5	36	May 18						
1883	107 6	May 17	99	Dec 26	30	April 9						
1884	107 8	Aug 9	98	Jan 23	30	May 22					24 00	Jan 24
1885	113·6	July 27	100	Jan. 23	32	June 4	......	......	......	......	15 25	Dec. 4
1886	108 8	July 5	99	Jan. 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec. 9
1887	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1121 58	25	15 00	Feb 4
Means	117 1		99		40		12 12		986 23	22	18 06	

Year	Rain: Total for Year	Mean Y'rly Rainfall at Town Hall and Mid Ry Stn on surface of g'rnd	Gr'tr fall on srfce. at Tn H'll & Mid Stn than at 65 ft ab've surf at Exe: Depth in Inches	Percentage of fall at Exch'ge	Greatest Daily Fall during Yr	Date	Snow: Last and First Snow of Seasons: Date of Last Snow	Date of First Snow
	Ins	Ins	Ins	Per cent	Ins			
1869							April 3	Oct 19
1870	24 120				0 820	June 18	Mar 24	Nov 15
1871	21 640				0 965	June 16	Mar 15	Nov 16
1872	42 060				2 430	June 19	May 11	Nov 13
1873	21 440				1 200	Aug 4	April 25	Jan 3, '74
1874	23 560				0 740	Dec 7	May 9	Nov 26
1875	30 280				1 700	Nov 15	Mar 12	Nov 9
1876	35 270	39 788	4 518	11 28	1 810	Oct 9	April 12	Nov 8
1877	40 150	45 499	4 849	11 19	1 420	July 16	May 19	Oct 15
1878	35 434	39 010	3 576	11 01	1 220	Aug 14	April 1	Nov 8
1879	28 017	40 248	2 281	10 82	1 020	June 8	May 7	Nov 20
1880	35 690	39 616	3 926	11 10	1 710	Oct 27	Mar 2	Oct 27
1881	35 434	39 652	4 458	11 26	1 435	Oct 13	April 20	Oct 29
1882	39 683	43 103	3 420	10 86	1 608	Dec 6	Mar 21	Nov 19
1883	34 396				1 348	Sep 26	Mar 24	Nov 10
1884	27 657				1 170	Jan 23	Feb 28	Nov 23
1885	25 639				1 208	Sep 3	May 7	Dec 9
1886	35 993				2 140	July 26	May 12	Nov 6
1887	18 665				0 816	Oct 9	May 21	Oct 14
Means	30 872	39 601	3 860	11 08	1 379			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The sunshine is recorded in hours and minutes by glass sphere on cards fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 66½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1876 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the eighteen years ending with 1887 is 30·872 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 34 292 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

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